

The AMSAT[®] Journal

Editor

Russ Tillman, K5NRK

Editorial Staff

Ron Long, W8GUS

Buzz Gorsky, WH6I

Andy Reynolds, WD9IYT

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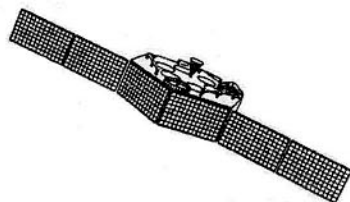
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Ron Ross, KE6JAB at Patriot Hills, Antarctica! Through innovation and effective planning KE6JAB was able to work digital satellites during a visit to Antarctica. Ron shares this interesting story and adventure with Journal readers. (Photo by Sheryl Schindler)

Blue Ice Transmissions: Amateur Satellite Radio in Antarctica, December 1997 - January 1998

Ronald Ross, KE6JAB (ronald@thistle.org)

The idea for a trip to Antarctica began ten years ago. I had wanted to travel to the North Pole in 1987, but for the usual everyday reasons I did not do this. I regretted this for many years after, therefore when the opportunity to go to the South Pole arose in early 1997, I vowed I would not let this chance go by for any reason. We arranged to travel to Antarctica and the South Pole in December 1997 and return in January 1998.

Getting to the South Pole is not easy. It requires money, time, and the cooperation of the weather. Getting back also requires the same. In preparation for the trip my wife, Sheryl and I spent many hours watching video of past trips, reading books and talking to anyone who had been there or was indirectly connected to someone who could convey something of the

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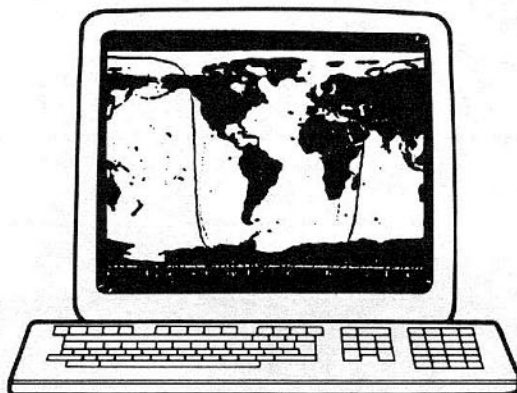
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Telephone: 301-589-6062 Facsimile: 301-608-3410
AMSAT-NA Club Call Sign - W3ZM
AMSAT WWW: <http://www.amsat.org>

The AMSAT Journal Staff:
Editor in Chief: Russell K. Tillman, KC5JVB
Circulation: Martha Saragovitz
(martha@amsat.org)

Editorial Staff:
Ron Long, W8GUS
Buzz Gorsky, WH6I
Andrew Reynolds, WD9IYT

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Editorial Office: Russ Tillman, KC5JVB, 113 Rollingwood Drive,
Vicksburg, MS 3910-9510, Internet: kc5jvb@amsat.org, telephone and fax:
601-634-6398.

Advertising Office: AMSAT-NA Headquarters, 850 Sligo Avenue, Suite
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their talents, time, and efforts to produce The AMSAT Journal.

Apogee View

It's Your Journal

Bill Tynan, W3XO

From time to time, we receive comments; and even a few complaints like the following:

"The AMSAT Journal does not have enough technical content."

"Too many articles in The AMSAT Journal are too technical."

Yes, we get complaints of both kinds. But, what must be stressed is that the Journal is *YOUR* publication. Journal articles come from you, the members of AMSAT. That includes those affiliated with overseas AMSAT organizations as well as the North American personification. So, on occasion articles which have appeared in overseas AMSAT related publications are reprinted. Some of these require translation, which can slow up their appearance or even prevent publication altogether if a suitable translator is not available at the time. But, by and large, most of the articles that appear in these pages come from our own members. Thus it is up to you, what kind of articles appear. They can be on any subject relevant to amateur satellites, from techniques for constructing and testing the spacecraft themselves to how to build simple gear to use them, as well as tips on operating procedures suitable for taking best advantage of the birds that are up there.

Have you built a new converter or transverter to permit use of HF equipment on the VHF and UHF satellites? Have you come up with a neat new

simple to construct antenna design? How about modifications of narrow band equipment for the 9600 baud packet satellites? That's always a hot topic. Have you put together a portable satellite station? Why not describe it? Have you evolved some satellite operating techniques that others may not have thought about.

Then, why not take pen, or keyboard, in hand and write about it? Maybe your experience and ideas can be of benefit to other satellite operators or prospective satellite operators. Don't forget, there are many who read *The AMSAT Journal* who are not on the birds. Maybe seeing your experiences in print will be all that is necessary to get these folks in gear.

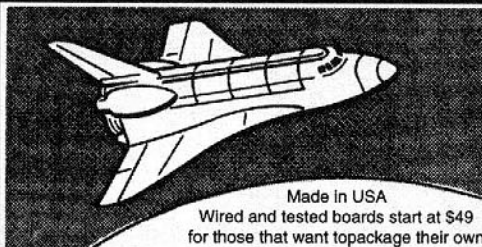
Articles don't even have to be about equipment or operating. Do you have ideas as to what kinds of satellites you would like to see AMSAT support after Phase 3D is safely in orbit? Do you harbor feelings concerning the direction your think the organization should go in the years to come? Where and how can we best raise funds? Do we need to maintain a central location with facilities for constructing future spacecraft? Or, should we go back to doing it in our garages and basements? Let us all in on your thoughts, and the reasons behind them.

The AMSAT Journal is the right vehicle to transmit to others your expertise in amateur satellites and their use, as well as to air your views on future projects and approaches.

It's *YOUR* Journal. It's not merely a one way communications link. You must transmit as well as receive. ■

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[Antartica continued from page 1] experience. It is interesting to note that not many people have been to Antarctica, and even fewer to the South Pole, though the number of visitors to Antarctica is increasing each year. It was fortunate that I knew some people at U.S. Geological Survey, who had been to Antarctica, in particular Art Ford, who regaled me with stories of his own polar adventures, and supplied me with maps and articles he had produced from his own research.

For camping and cold weather preparation, we went many times over the course of 1997 to the deserts of Northern Nevada, 350 miles from our home in San Francisco. We also tested the radio system mostly in the desert, trying to emulate the conditions and in particular trying to make things work in an environment with only what we had brought with us. Our home environment was not practical for getting antennas on and off the roof, therefore we kept things as simple as possible, when testing at home.

We would often leave work on a Friday afternoon drive seven hours to Nevada. We would set up a tent in a full moon, then spend Saturday and Sunday experimenting with radios, camping gear, clothing and anything that would prove useful for the trip south.

I had been planning on setting up a PACSAT station for a year or so, but hadn't gotten around to it, mostly because of the practical and domestic implications of the antennas.

I had always been interested in satellite communications, and had worked the *Mir* and the Space Shuttle while camping in the Nevada desert. These contacts I had been accomplished with a fairly basic setup.

Early in 1997, I had read an account of an attempt to fly to the North Pole by Scott Hamilton, N1VFW. He had sent back messages through the PACSAT's, while on board a plane going to the North Pole. This intrigued me. I thought while at the South Pole I could send text and images back to my friends and family via amateur satellite. One, it would force me into digital satellite comms, two, be a challenge, three, it would be fun to send messages back and forth from such a remote place. Therefore, the quest to put a system together began; it had to be portable, lightweight, and draw as little current as possible, yet provide reasonable throughput.

Field Testing PACSATS

In early September 1997, I put a message on the AMSAT-BB, asking what people thought might be the most compact and portable PACSAT station suitable for an Antarctic expedition. I received many messages and many recommendations, the consensus being an ICOM IC821H, a PACOMM modem, a combination of antennas. I had been using a FT530 HT and a linear amp with a Ringo Ranger up till this time, mostly for voice and packet communications while camping in the

deserts of Nevada and California. I had also been doing some ATV experimentation using a 70cm eggbeater, therefore I decided to go with the 2m Ringo for uplink and the 70cm eggbeater for downlink, and purchased an IC821H. While debating over which PACSAT to use, the 1200B or the 9600B, I came across an article written by Steve Ford, WB8IMY, on 9600B modems for PACSAT use. The article compared the performance of the Kantronics KPC9612 modem with several others. I had a KPC9612, but was unaware that it was compatible with PACSAT usage. A quick message on the AMSAT-BB let me know that quite a few hams were using this modem with good results.

Armed with a new radio, the modem and several antennas, I headed up to the Nevada desert for a short camping trip. This was now the beginning of the trial period for the PACSAT station. I also took with me a Toshiba laptop loaded with the communications software PB/PG. I knew about WISP, but didn't want to complicate things further at this point in time. My goal right now was just to be able to decode packets from any of the 9600B satellites. Using STSPLUS for pass prediction, I would manually point a Yagi antenna at the satellite and look for packets to be decoded. I had a strong signal but could not decode with any reliability.

This was quite a frustrating period, because I did not know whether the modem was not working or that I still did not have enough signal strength. Added to the above, a good pass is very short and happens only every few days. In the SF Bay Area I could not find a terrestrial 9600B packet link, which would have been a useful way to eliminate the modem as a problem source. I also sought advice from the local AMSAT coordinator, AA6PA; unfortunately, I never received a reply. Eventually I put the 70cm eggbeater on the roof at home, and hooked up a scope to the receive signal of the modem in order to look at the eye pattern during a good pass. As I had suspected, I had too weak a signal. The eye was blurred, noisy, and when I got data decoded it was for a very brief interval.

The KPC9612 had some options for amplitude adjustment and different filtering. Changing the default settings helped, but I really needed a preamp at the antenna. I had hoped to avoid adding any other electronics,



KE6JAB setting up the 70cm eggbeater on the bamboo pole while Simon, a campguide watches.
(Photo by Sheryl Schindler)

but it was clear that I needed to add a preamp to my minimal setup.

In the meantime I had been trading experiences with Chas Richard, W4HFZ. He had spent quite a time perfecting a mobile PACSAT station and many of his observations saved me a great amount of time. On his advice I chose to get an ARR preamp, which had good specs, was compact, and could be supplied with power from the coax. This worked fine and got me to a point where I could now decode data reasonably. I tuned the Doppler shift manually and lived with the fading.

I later purchased another preamp from SSB Electronics; this was for comparison and secondly because it had relay switching for RF transmit on the 70cm band. I was worried that I might fry the ARR preamp with an unintended transmission. Ultimately, I took both with me since the ARR was so compact; both performed well.

At this point in time I was confident of the reception. It was not great, but I predicted it would be better in Antarctica, given less local interference, but I had not tried to upload any messages yet. When I did try to upload, the competition in and around San Francisco left me somewhat at a disadvantage with no directional antenna for the uplink. I managed to be heard once by UO-22, but could only get a DIR command through. I still worried about the modem at least for the transmit side. The question of a transmit antenna was still unresolved at this time. I had been advised against a 2m eggbeater, but decided to order one from M2 and give it a try. Again, I had to consider the mobility and the compactness of everything I was taking.

Meanwhile, preparations for the trip in general, were moving into high gear. In addition, I had just started a new project at work which demanded many extra hours. Before leaving for Antarctica we wanted to do some cross-country skiing in preparation for the trip, but no real snow had arrived yet in the Sierras. The Thanksgiving holiday was too close to our departure date south, so we swapped our Thanksgiving holiday for a 3-day weekend two weeks earlier, and decided to head back to the Nevada desert for a camping trip. This would be our last chance to get the PACSAT station running out in the field, and our last chance to try out all the gear we planned on taking with us. Therefore this was the last dry run.

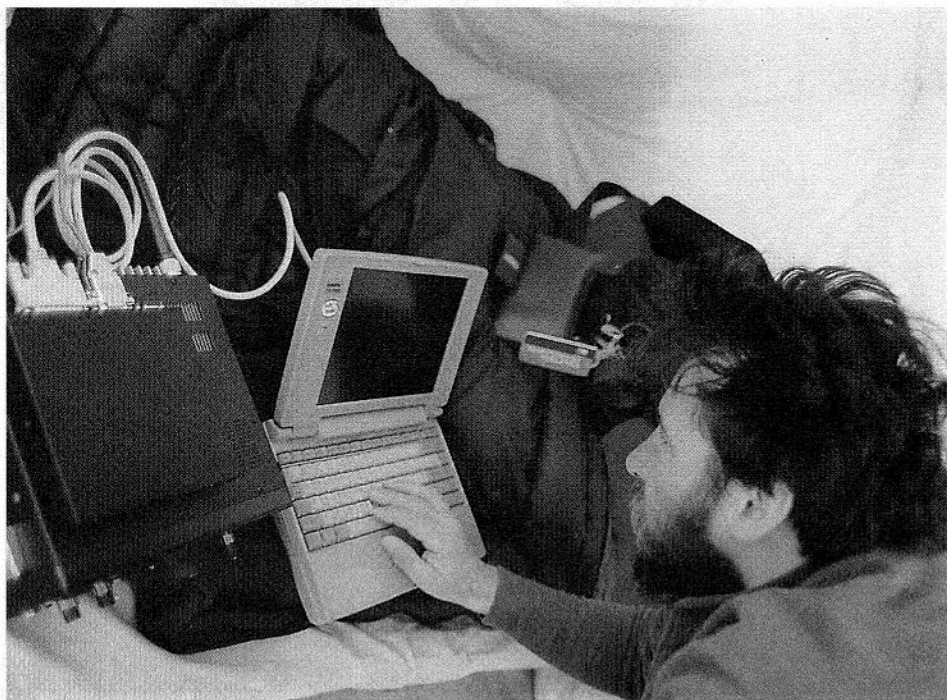
The only way to get to the interior of Antarctica and to the South Pole privately is with an expedition company called ANI. They have been providing logistical support for private, polar expeditions for a number of years. They have a base camp 600 miles from the Pole at Patriot Hills, and use a nearby blue ice runway for wheeled aircraft to land. About 100+ adventurers and tourists travel with ANI each year. I had been e-mailing ANI in order to find out more regarding the facilities at the base camp and how I could get DC power for my PACSAT setup. Before we left on our 3-day weekend camping trip I received a fax from ANI. A bad storm had damaged the wind generator just a few days earlier, severely limiting power availability at the camp. Therefore, they advised against me bringing all my radio equipment, with the possibility of not being able to power it. This was not the kind of news I wanted to hear. We decided to ignore this message and departed for the high desert amid the possibility of rain and snow showers on the desert floor.

We arrived at our usual camping spot, pitched our tent, set up the antennas, the radio and the modem. I always carry a deep cycle gel cell battery and a solar panel for DC power while camping. After running down the car battery too many times in remote locations I have found the combination invaluable. Later the next day, there would be four good passes for UO-22 and KO-25. This would be the first use of the

2m eggbeater and this was the time for it to perform. We turned in early trying out our extreme weather sleeping bags, good to -30F. The next morning a nice frost had developed on everything, inside and outside the tent. It was +10F; we had slept warmly in the goose down bags.

I prepared two short text files to be sent to Jerry Smyth, N8ULU, and one to Roy Welch, W0SL, two hams that I met through the AMSAT-BB. During the first pass of UO-22 I managed to get one file uploaded, and got the other off on KO-25. I was pleased to say the least. Bolstered by this success, I told my wife there was no way I was not taking this setup to the Pole, No Matter What! That weekend, out in the desert it blew, it snowed, it rained. I got one more test message uploaded, and saw a reply from W0SL, but could not download it. We tested cold weather clothing, Gore-Tex wind protection and everything else we were taking to the Pole. We were ready for Antarctica. We just needed to get through the next few weeks of preparation and the eventual rush of last minute panics as the departure date drew near. However, a few other surprises were in store for us.

On returning home I turned my attention to getting WISP up and running, as this would make things so much easier. Roy, W0SL, was surprised when he heard I was using PB/PG, WISP would make full duplex operation possible and really was the type of



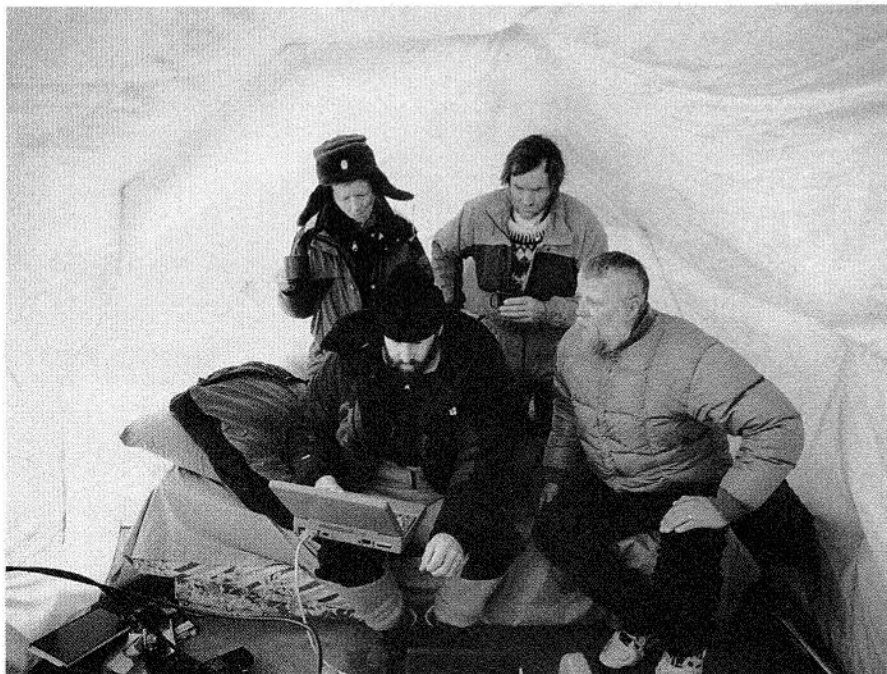
KE6JAB in his tent during a PACSAT session. The equipment setup is on his sleeping bag. (Photo by Sheryl Schindler)

software package needed for this kind of application. I was instantly impressed when I got WISP running and realized how bare bones my previous operating setup had been. For pass prediction I used STSPLUS, another great software tool which I had been using for a number of years.

Final Preparations

I managed to get a few more practice sessions in at home before having to pack up all the gear. Yet, I still had only uploaded and downloaded messages of less than 2K, not any images. I was still concerned about the setup, especially the modem transmit side. Sending and receiving messages would be OK, sending images would be a bonus. The major benefits I would enjoy while in Antarctica were, at such southerly latitude, there would be no competition for the uplink channel, and a large number of good passes over the day every 90 minutes. I was counting on those two advantages to pull me through.

During the course of my preparing the PACSAT setup, I had asked Jerry, N8ULU and Roy, W0SL if they would receive my messages and images from Antarctica. In turn they would forward those via the Internet to my longtime friend and fellow camper Ed, KE6IZN, to post the images on my web site. For text messages, I had set up an Internet mailing list for all interested persons to subscribe and receive those messages from Antarctica.



Assembled audience watching a PACSAT session. Art Mortvedt, KL7RL next to KE6JAB. Behind are Max the Cessna Pilot (I) and Lisa a campguide. (Photo by Sheryl Schindler)

I sent a long reply to that fax I got from ANI outlining my reasons for taking the radio equipment, my goals and the fact that I would not be thwarted in my efforts just because I could not get 12 Volts DC from them. I was glad to get a reply a few days later, stating they would welcome me bringing my radio equipment, but to come as self sufficient as possible. That meant that I would need to take a battery, something I had not planned on.

The weight allowance for the Antarctic flight was 50 lb/person, over that the charge was \$30/lb. The radio, laptop, antennas, feedline and all the peripherals easily took up a big part of that allowance, and did not include my clothing and other personal items. Having to take a 10-15 lb battery would now blow that allowance sky high! The weekend before leaving, I shopped for a light gel cell, I got a 10Ahr and a 18Ahr. The 10Ahr was fine but I decided to go with the 18Ahr just to have a bit more margin, though it would cost in weight, 12 lbs.

While trying out those batteries on the last weekend, I mistakenly reversed the positive and negative terminals. I noticed a spark at the terminals. The IC821H would not turn on. Had luck finally run out? No, it had just arrived. The ICOM engineers must have foreseen blunderings like mine, and placed a reverse biased diode across the line, and fuses in the DC power cord. A quick change of fuses and I was back in business; phew!

close!. That spare *Pole* kit needed to be rechecked for such eventualities.

Well the excess weight problem would have to be resolved later, for now the focus was to make sure we checked and rechecked all our gear in addition to the radio equipment. We could not depend on getting any other supplies once we left San Francisco. I packed most of the equipment into two soft travelling bags, the antennas, the radials and fragile stuff was wrapped with heavy woolen socks, thermal underwear and fleece sweaters. The feedline, Belden 9913 and LMR 400, was coiled up with the preamps secured inside the coils, somewhere in between all this was the battery wrapped inside two plastic ziplocks. The radio I carried in a photography shoulder bag, along with the laptop and modem in my rucksack. I had to hand carry the 2m-eggbeater antenna stick, it was too long to fit in the bags. This caused the most frowns at airport security, especially in S.America, but when I mentioned ham radio, that seemed to dissolve suspicion.

We had planned to take images from our camcorder using a frame grabber and send those images over the satellite. My wife, a photographer, had managed to persuade Olympus into lending us a D500-L Digital Camera for the trip. But it was due to arrive the day we would depart. By a miracle of FedEx, we got the camera two hours before leaving for the airport. We needed to test it and load the software onto the laptop from CD-ROM; just before the taxi arrived we got an image downloaded into the laptop. Getting that camera proved to be a big plus, as the images were so much better and smaller in memory size, than would have been with our original plan. Yet, saying that, it also added another pound to the already excessive weight total.

Our route to Antarctica would be from San Francisco to Miami, to Santiago, Chile, to Punta Arenas, which was at the southernmost part of South America in Chile, just across from Tierra del Fuego, Argentina. There, we would meet up with others at the ANI office and fly onward to Antarctica onboard a chartered C-130 Hercules transport plane. The flights down to Punta Arenas were without incident; we got a nice view of the Andes Mountain Range, and our first sight at a glacier on the way to Punta Arenas. We had left the Northern Hemisphere just before it's shortest day and arrived in the Southern

Hemisphere for it's longest day. It was a welcome change to be able to walk around till 11:30 PM in good daylight, plus it was 60-70F during the day.

As stated earlier, getting to the Pole is heavily weather dependent. Thirty of us went out to the airport with all our gear, ready to fly, only to be informed that we could not go due to high winds at the basecamp. The runway at the basecamp was an icefield bordered by the Patriot Hills; the Hercules could only land in winds less than 15 knots, otherwise it would slide uncontrollably. The next day we could not go for the same reason. I found an Internet cafe in town and was able to file my first report, though not via amateur satellite. As for the weight allowance, I managed to have someone carry my radio bag, and someone else to take a few items, but between my wife and I, we were still 30 lbs over the weight limit and would have to pay \$900 for excess, unless we worked something else out.

Patriot Hills

After one more day, we finally left Punta Arenas for Patriot Hills, Antarctica, a 1500 mile, 6 hour flight. The cloud cover was not too bad and we were able to see our first icebergs, pancake ice and packed ice and then the vast snow landscape that is the Antarctic continent. I had imagined the blue ice runway to be very smooth, therefore I was surprised when we landed with quite a crash and the Hercules seemed to heave up and down as we rushed to the end of the runway. Later, as I walked across the runway it was obvious, the ice was more like a frozen piece of ocean, with all the usual undulations and occasional long and narrow crevasses.

We settled in to our tent, enjoying everything new, and especially the 24 hour sunlight. The temperature was around +15F. We remained on Chilean time for practical reasons, though we were now at 80S, 81W, a few more hours eastward, but who cared. I went to work, eager to set up the antennas and the radio gear; I got most of this done before having to turn in for a sleep. It was quite unusual to be sleeping with so much light, and waking up always with light. I came to enjoy this over the course of the trip, but also welcomed the darkness on our return to Punta Arenas; darkness seemed such a more natural thing for sound sleeping.

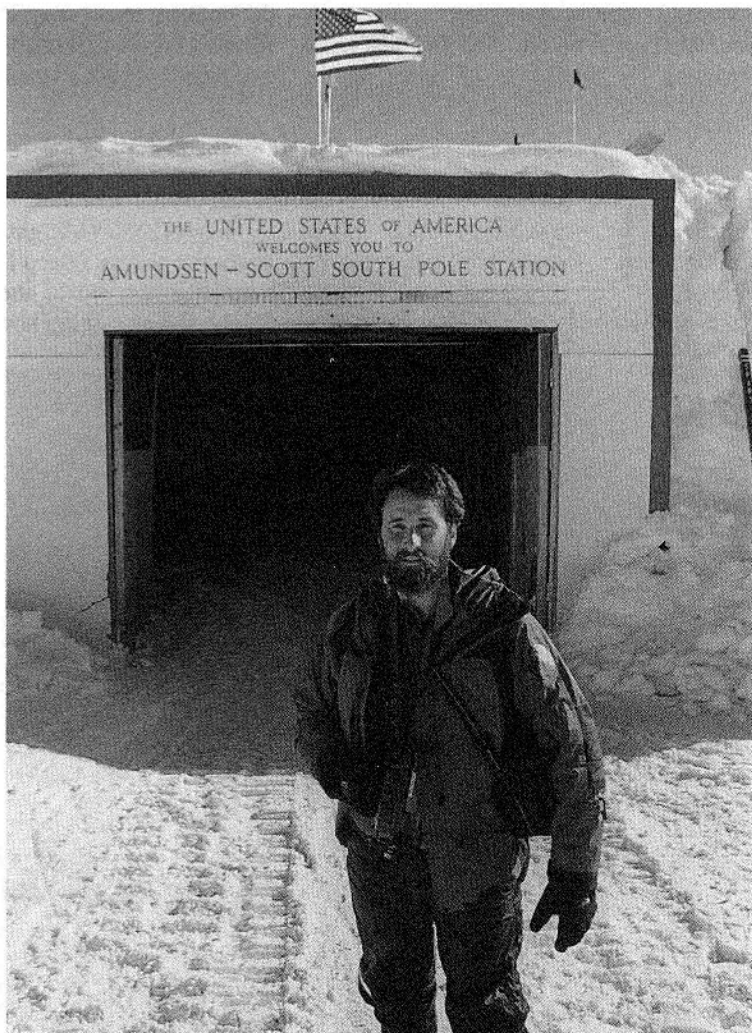
The next morning it was clear and windy. I got two 8 foot bamboo poles from the camp supplies and secured an eggbeater antenna

and it's radials on each one, put the preamp on the downlink pole, and placed each pole on either side of the tent. The tent had a snow wall on each side in order to let the wind blow over the tent and not against it. The poles were driven into the accumulated snow and ice that had built up around the wall. A feedline to each antenna was laid out and fed through a pocket in the side of the tent. The radio, modem and battery were unpacked and carefully set up on my sleeping bag; everything seemed to have survived the journey. The next step was to get the local and UTC time set correctly for pass prediction. We were 3 hours behind UTC, a sat pass of UO-22 was coming up soon. I was only ready to monitor the radio receive signal for this pass, I had thought about this moment many times over the months, wondering if everything would be work the same down here. Sure enough, as predicted by STSPLUS, as the elevation increased on UO-22 the needle started to flicker right and a strong signal was observed; test one was over. Another good

pass was due in 90 minutes. As I waited for the next pass I fired up WISP and prepared a short message to be sent to Jerry, N8ULU. The subject line was "we're here", the message was "Hello Jerry, we made it! pls. rply. RR." I had a followup message much longer in the buffer describing our flight from Punta Arenas. Just 15 minutes before the pass I rechecked all the cables and discovered that I had plugged in the 1200B cable not the 9600B modem cable that went from the KPC9612 to the 821H.

When I looked for the 9600B cable I could not find it; I frantically searched in vain, dumping things out of bags onto the floor of the tent. I did remember packing this, but was beginning to feel quite a chump if I had come 8000 miles and brought the wrong cable. My mind was racing thinking that I could rewire the 1200B cable, as I had brought a soldering iron with me and some spare connectors. While I was figuring this out I felt a lump under me, got up and looked under the sleeping bag, and there was the 9600B cable; phew!

I connected the 9600B cable and saw some data from the satellite but had missed most of the pass during the cable panic. I would have to wait for the next pass in order to upload my first message. The next pass came, it was one with higher maximum elevation. Just as before, the needle flickered into the red zone on the IC821H, right on cue. WISP responded with an upload request, the request was granted and the file was uploaded, then the next one. I was



Ron Ross, KE6JAB at the entrance to the Amundsen-Scott South Pole Station. (Photo by Sheryl Schindler)

shocked it had worked so easily and I had no other messages to send. Nobody else was logged in, and at least five more minutes of the pass was left. WISP began to update my directory, which was seven days out of date. I was elated. I shook my wife awake to tell her the news. This was the first of a few middle of the night wakening she had to endure. The rest of that day I had a permanent grin on my face; all those months of testing, frustration, worrying if I would get everything transported, and whether it would work, had finally paid off big. It felt very satisfying indeed.

The others at the camp were happy at my success, though a little confused by what it all meant, at first. The next big thrill was getting a message back from Jerry, N8ULU, a day later. I can't say how strange this seemed, having the message pop open on my laptop screen was a surprise when it happened. The strangeness was not the virtual communication which I was used to, but then going out of our tent, realizing how physically remote we were. I could see mountain ranges on one side then just snow stretching for thousands of miles on the other side with nothingness till the coastline.

Each time I got a message back made me think of how it must have been for the Astronauts who traveled to the moon, hearing voices from Earth; very weird. When I got the reply from Jerry, I again woke my wife to let her know that was

another grin day. After this I began to get messages from other hams around the world who had been downloading my reports to Jerry, N8ULU, and Roy, W0SL, those messages were warmly received. The best passes for my setup happened to start after midnight local time and continued till roughly 9:00 AM. Each night I would get 5-6 good passes on UO-22. Each morning the other people in camp would quiz me, wondering what new messages had arrived from the world outside. My intention had been to send text on UO-22 and images on KO-25, but I could not make a link with KO-25. For the first week I stuck to UO-22.

The next test was to upload an image. We had been having problems with the digital camera; the batteries would run down very soon after powering it up. We thought it might be the cold, but I think the NiMh batteries had not been charged for a while, each subsequent charge appeared to make them last longer. A photo of a penguin from the rookery back near Punta Arenas was selected for the first image upload, and after two passes we got it uploaded successfully.

I still had not seen anyone else logged onto UO-22; I also noticed how I experienced less fading than I was used to in SF. A strong signal was achieved right after rising above the horizon then a deep fade, then a strong signal till the end of the pass, with little fading. Later I noticed how strong the signal

from the satellite could be. Without turning on the preamp I would see the QST message from UO-22 on the WISP screen.

A few days later and always on the early morning passes, as the satellites worked their way down S. America I could see other hams logged into both UO-22 and KO-25. Further tweaking of my setup allowed me to send images on both KO-25 and UO-22. At times, I was sending two to three images a night. The best I could achieve being a 70 Kb image in one pass. I found that KO-25 was a better *listener* than *talker* and the opposite for UO-22. However this difference was quite marginal. My main problem when operating was tuning the Doppler shift, not that I couldn't do it, but that I got distracted by things on the laptop screen and was quite far off when I looked back at the radio receive signal.

The PACSAT station drew quite an interest in camp, and often I would have a few other people sitting in our tent watching messages get uploaded and downloaded from far off places. We all eagerly awaited that screen to pop up with personal messages. Some of those were from my Mother, via AOL, via Roy, W0SL. This was the first-ever computer experience for her, and for other people on the mailing list. Other highlights were being able to send a picture taken at the South Pole and to know it had been posted on the WEB site not more than ten hours later.

To the Pole!

For the trip to the South Pole we had to wait several days for the weather to clear at the refueling area and at the Pole Station. I have included in this article a clipped version of the report I sent back on the PACSAT.

Sunday, 12/28/97, Patriot Hills. South Pole Day

At 0900 this morning we get a new weather satellite image. The conditions look good for our trip to the Pole. Six of us including the pilot and a mechanic lifted off in a Twin Otter aircraft around 1030. The first thing we notice in the air, is that base camp looked like a small speck in the valley, you could easily miss! After we climb to 9500 ft our first views of the crevasses begin to appear below. One area we pass over has many parallel lines with snow bridges across the crevasse; they look about 1/2 mile long by 100 ft across, perhaps 150 ft deep. It is quite interesting to see how equidistant the lines



Success! Ron Ross, KE6JAB at the Geographic South Pole, December 28, 1997. Note the stud markers to the right and rear of Ron which mark previous South Pole positions. (Photo by Sheryl Schindler)

are to each other; they appear regularly spaced even when they have a bend in the line. The pattern from the air looks too precise, almost man-made in some places. Later we see other crevasse fields, which appear more chaotic though looking hard enough we still see some regularity.

For three hours we fly, then approach the Thiel Mountains. Somewhere below in the valley is a fuel cache of some thirty drums of aviation fuel. The pilot quickly spots it and circles round to check the landing area. When we land with the skis it is very smooth and the plane slows very quickly, unlike a wheeled aircraft. Outside, the wind is howling. The light from the sun is very bright. The sky is cloudless blue. We all deplane while the pilot and the mechanic refuel from the drums. This is not a place to be unprepared, the snow on the ground is soft and very carved with the constant wind. The blowing snow flows much like you see blowing sand in the desert, shaping the ground below it.

The scenery, with the Thiel Mountains in the background is very impressive, we feel very dependent on that aircraft in the midst of this vast space. As a matter of course we carry all our camping gear and enough supplies for one week, in case of some mechanical problem. I took my gloves off to better handle my camera and they are instantly frozen by the vicious wind. It's not possible to face into the wind for longer than a few minutes. My GPS says we have traveled 346 miles from the basecamp, 300 more miles to reach the Pole.

Once we take off it appears that the backside or southside of the mountains is a plateau, which climbs as we head to the Pole. We don't pass many mountains on the way to the Pole but the ones we do see are just the tops not quite buried by snowfall yet. I imagine the ice breaking as it moves over some landmass just below the surface causes the crevasse effect. Now over the Polar plateau we start to climb up to 11000 ft, and the cabin is unpressurized, some of us begin to feel early effects of altitude sickness. About 30 minutes from the Pole, we spot the 3 Icelanders who have been skiing to the Pole from Patriot Hills. They are dressed in red and they wave as we lower altitude and speed. The sight of them in this vast expanse is another reminder of the sheer size of the areas below us.

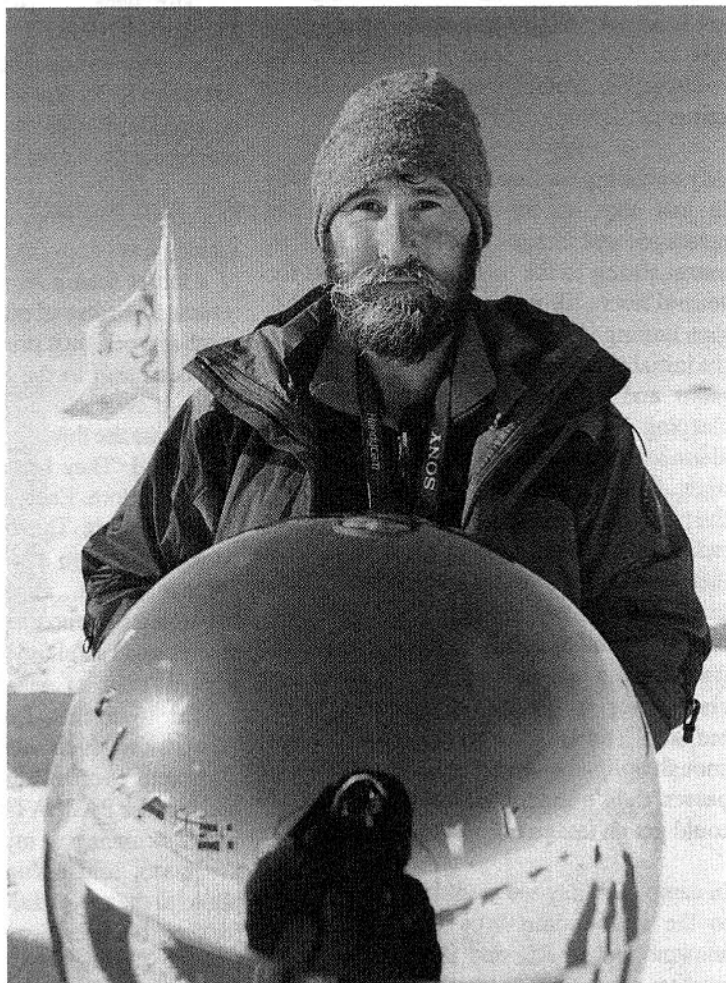
A few moments later we land at the Amundsen-Scott South Pole Station, the South Pole Station operates on New Zealand time, 17 hours ahead of our time, it is now 0930 NZ time. The sky is completely blue, the snow sparkles very brightly, the air is very thin, it is -30F, slight gusting, we have made it to 90 South! A NSF person greets us, her name is auspiciously Hillary Everest, and her name tag is upside down. The NSF operates all the US bases in the Antarctic; Hillary is just down here for two months from Washington, DC to oversee the progress of the science projects.

My first impression of the base is a mixture of something futuristic and a very large building site. They are expanding the size of the base to accommodate more projects and people. Expected to finish in 2003! The original structure is a geodesic dome shaped building, which looks large from the outside but surprisingly small, and cramped inside. The temperature inside the dome is a constant -50F!!! It is filled with many small container-like boxes; some are work areas some living quarters. We get to visit the comms area and meet a ham, KC4AAA, who works other people in Antarctica and the US. The people at the base seem quite agitated and surprised by our visit, the most interesting thing I see is the greenhouse; it can produce enough greens for one salad for one person per week! We also visit a recreation area, which is filled with computers, allowing people to log onto the Internet from the South Pole!

Eventually we head outside to the ceremonial pole and take many pictures

and video; there is a short barber pole-like marker with a mirror globe on top, surrounded with flags from the countries that signed the Antarctic Treaty. About thirty yards away is the Geographic Pole marked by a brass stud on a copper pipe. There is a long line of these studs marking previous years, as the ice mass is moving constantly. They seem spaced about thirty feet from year to year. My GPS says 89.9998S and as I walk the longitude changes, I am walking round the world in about ten paces!! With the slightest gust things get very nippy out there, I stopped for a few moments to savor the moment with some whisky from my hip flask. Most of us are quite dizzy with the elevation; 9600 ft, and climbing stairs really gets you out of breath fast.

We make our way back to the Twin Otter, which is sitting just one hundred yards from the Pole in front of the Dome. We depart and on our return we circle over the Icelanders again, they give us a big wave, it has taken us just twenty minutes from the Pole, they will travel another two days to reach it. The



Ron and Sheryl (reflection in the globe) Ross at the Ceremonial South Pole, December 28, 1997. (Photo by Sheryl Schindler)

GPS onboard the aircraft does not work when the craft is too close to the Pole, so the pilot heads on a reciprocal heading to his arrival. After ten miles the GPS is back working again. For the return flight we have a tail wind and the pilot hopes to make it back without refueling, so he climbs to 13000 ft, most people have a headache or nausea by the end of the flight. We still need a squirt of fuel and we land again at the Thiel Mountains. This time, the wind has dropped. It's still very cold but quite serene. Scott said on his travels to the South Pole that "it was an awful place". He must have had bad weather constantly. Back in the air the speck of the basecamp comes into view. We land and have a few drinks. It has been a very long trip. We head for our tents. We made it to 90S.

Final Days at Patriot Hills

The 18Ahr battery lasted for about one week before needing to be charged. The wind generator in camp had been fixed, but I was able to borrow a solar panel that normally lived on board the Cessna plane used at camp. That allowed me to be independent but I had not brought an inverter, and had to rely on AC power from the radio tent to recharge the laptop, camcorder and digital camera.

My operating routine for the first week was to just stay up till whenever I got my messages and images uploaded. This often meant sitting in the coldness of the tent for several hours till around three or four AM, then turning in for the rest of the night. Once the initial excitement died down, I placed the radio and modem on a box beside the sleeping bag and would have my watch alarm set for each upcoming pass throughout night. I would wake up five minutes before the pass, get the laptop running, turn on the radio and modem, upload a message, and then shut down everything, all without getting out of my sleeping bag. The only time this routine failed was when the wind was blowing so hard that I never heard my alarm over the sound of the tent being buffeted. Towards the end of the trip I had enough uplink bandwidth that missing good passes didn't matter so much anyway, I could get an image off, with relative ease.

In camp each day we would take short trips to the surrounding hills and glaciers by snowmobile or ski, and if extended good weather permitted we would take a tent and food supplies for a few days camping. Each night I would send back a report of the things

we had done and seen, and sometimes send an image of the local terrain. Between Christmas and New Year, we had excellent weather, clear blue skies, light winds. On New Year's Eve our first blizzard hit, and we had whiteout for eight hours. Visibility was down to about 20 feet. Everywhere you looked it was white, quite a disorientating experience. But it seemed more fitting to this hostile environment than the previous week's weather. Those two weather patterns summed up many of the feelings we had for what we experienced and saw in Antarctica. The landscape could be so inviting when the weather was calm, but the weather could change quickly and make a peaceful, serene setting become so deadly and dangerous. I never thought it was a place for humans, especially the interior, where nothing was alive, not even a bug, nothing but snow, ice and rock. We really appreciated the greenery when we got back to Punta Arenas.

We had one other ham in camp, Art Mortvedt, KL7RL, who was from Alaska, and would often get a phone patch on 20m through Bob Hines, K4MZU in Atlanta to his wife, back in Alaska. In the early hours January 1st, I talked to Bob, K4MZU. The signal was strong and clear. We were in Art's tiny Kelty tent while the blizzard raged on outside, it was quite a thrill. I recently received a QSL card from Bob, K4MZU.

Our return date from the basecamp to Punta Arenas was set for January 5th, this was more of a target than a reality. In fact we never returned because of poor weather for almost another week. Just prior to this a Twin Otter had been sent to the South Pole Station to pick up two expedition groups. The first group was the three Icelanders; a father, son and friend. They had left Patriot Hills two months before. Each pulled a sledge all the way to the Pole. The second group was three Australians, who also pulled sledges from Birkner Island, much further Eastward, beginning two months before and they also made a successful trip to the Pole. When they arrived back at the basecamp we were treated to a first hand account of their experience, which was truly fascinating. We took pictures of both groups and sent images back on the PACSAT station. Ed, KE6IZN, who was managing my web site back in San Francisco, sent a copy of the Icelandic's photo to their expedition web site in Iceland for their families to see.

A day later, Olafur the father on the Icelandic expedition told me he had just talked to his

wife in Iceland, using the Satphone in camp. His wife and family were so relieved to see how healthy they all looked in the picture they had received; it was all possible by amateur radio. Olafur was so happy, and I felt glad I had brought this PACSAT station, and proud of all the amateurs who had made such a system possible. This single event made it all so worthwhile.

Earlier, we had taken a picture of a Polish adventurer called Marek Kaminski, who is well known in Europe. This image also made it to his expedition web site. Both those events drew a number of hits to my web site, when I returned more than two thousand hits had been logged from all around the world and it's still continuing today. All the original uploads and reports are available on the web site, along with many more images that were taken.

The weather cleared, and on Sunday morning the January 11th I filed my last report to Roy, W0SL from Patriot Hills. I then spent the next few hours dismantling the PACSAT station. I had sent over 70 messages; eleven of them were images. It had been a great success, and things had turned out even better than I had hoped. Almost six hours later the HERC landed on the blue ice runway, to take us back to Punta Arenas. I was still carrying that 2m-eggbeater antenna stick. We took one last look at the camp then departed. Four hours later we saw our first sunset in three weeks, and three hours after that had our first shower!

Back in Punta Arenas at the Internet cafe I was able to look at my web site and see all the messages and images posted. Ed, my friend who had moderated the mailing list summed it up for me in one message, and I quote.

"It's been fun living this vicarious adventure. It all seems to have happened so fast, and I don't want to go home yet."

It was a great adventure; the radio part was a super experience. We hope to go back to Antarctica one day soon. I'm very grateful to all the people in and out of AMSAT who helped me, especially Roy, W0SL, Jerry, N8ULU, and Ed, KE6IZN.

The complete text of this article also appears on my web site, <http://www.thisle.org>, with links to some of the pictures we took. ■

An Inexpensive Elevation Rotator: Model OZ1HEJ

Ib Christoffersen, OZ1MY

Michael Pedersen, OZ1HEJ is a very constant contributor to the AMSAT-OZ Journal especially about weather satellites and pictures. He is well known to our readers for his many home brew constructions. He has received weather pictures from the NOAA satellites for many years but not in the HRPT format. After he considered that, he realized that it would be a good idea to have an elevation rotator in order to follow the satellites. This started the construction of an economical rotator. Since Michael does not want to pay too much money for anything it has taken some time and experimentation to make it perfect; but now it is working.

The Basic Construction

The basic idea is to use a cordless drill to drive a threaded 12-mm rod, which in turn is connected to the elevation boom by means of the bearing. It is a very strong construction and the angular velocity is high. You can often find inexpensive drills at the local building markets. In order to make it easy for others to build the rotator, OZ1HEJ has used parts that are easily available; at least in Denmark. The only exception is the main bearing that carries the load from the boom to the 12 mm thread. This bearing is made for 100 DKr (about \$15 USD) and can

be supplied by Henning Hansen, OZ1KYM, Stubben 4, Ebberup, DK-5631, Denmark.

Figure 1 shows the hinges are ordinary door hinges, the four stand-offs are made from a brass curtain rod, and all the clamps are exhaust pipe clamps that have a better grip than the ordinary antenna clamps. A bicycle spoke transfers the elevation angle information to the potentiometer inside an aluminum box, which also contains the control relays and the electrical end stops.

The base plate is made from two sheets of 3-mm aluminum and carries the stand offs for the fixture for the motor, the three hinges for the elevation boom, and the mast clamps.

The mounting plate for the drilling machine is also hinged in order to allow it to turn as the elevation angle is changed. This is probably easier seen in Figure 2. It should also be possible to see the bicycle spoke that is connected between the elevation boom hinge and a small arm connected to the potentiometer in the box.

To weatherproof the drilling machine Michael has used a plastic food storage container. (After first emptying it!). The 12-mm threaded rod and the drill chuck should be covered and protected from the elements as well.

The difficult part of the construction is the main bearing but it is made by Henning Hansen, OZ1KYM who is a well known Danish satellite DX'er. He will supply the bearing and the 12-mm threaded cylinder and the heavy rods.

I have deliberately made this description very short since I anticipate that some of you will want to use material that is readily available in your part of the world. In this case this short description is meant as inspiration. If you want to build the rotator as it is here, we will be happy to supply 14 pages of drawings. And, in case you can read Danish, a 13-page description of how to build the rotator can be provided as well. If there should be a demand for an English description, I will translate it. However, this is a big job so I will wait and see what demand there is for documentation. You can contact me via e-mail at oz1my@amsat.org or postal mail:

AMSAT-OZ

The Engineering College of Copenhagen
Electronics Department
Lautrupvang 15
DK-2750 Ballerup
Denmark ■

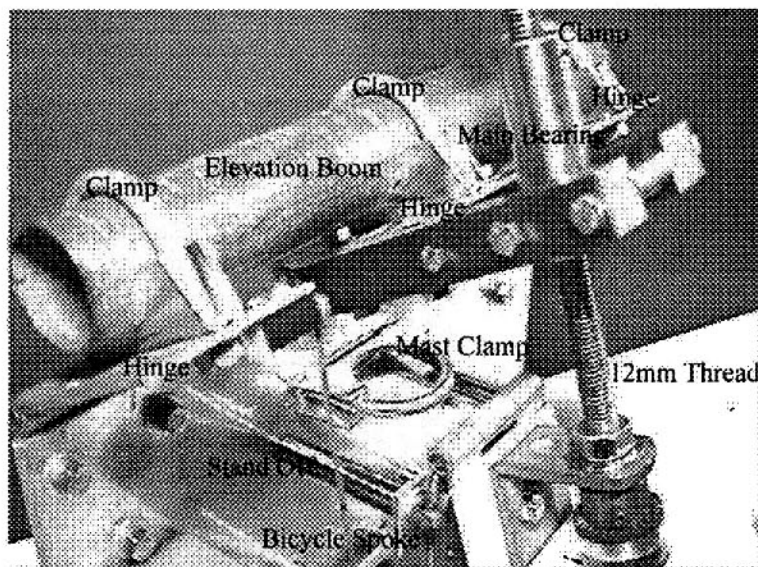


Figure 1. OZ1HEJ Elevation Rotator.

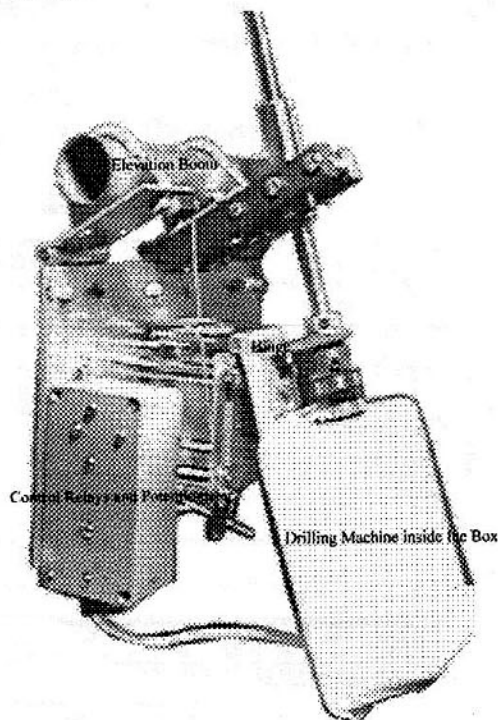


Figure 2. Drill mounting plate for OZ1HEJ Elevation Rotator.

Sputnik 40 (RS-17) Recordings & Analysis

Richard Goode, W8RVH and Farrell Winder, W8ZCF

My attention was captured in August of last year when a notice in reference to Sputnik 1 appeared on the AMSAT-BB from B.J. Arts, WT0N. Since I recalled listening to Sputnik 1 and experiencing its excitement back in October, 1957, I read WT0N's note with renewed interest. I am certain that there are many of us who remember Sputnik 1. His notice told of an agreement between Russia and France to commemorate the 40th anniversary of the launch of the first artificial Earth satellite which was Sputnik 1.

A one-third size functional model of Sputnik 1 commemorating the event would be launched from the *Mir* Space Station. The satellite was named Spoutnik 40. *Editor's Note: The spelling of this satellite varies from language to language. For example in French it is spelled Spoutnik while in Russian and English it is spelled Sputnik.* The construction of the model was to be delegated between two groups of high school students. One group from Reydellet School on La Reunion Island would build the radio transmitter. The other group from Naltchik in the Russian Republic of

Kabardin-Balkar would build the satellite structure and antennas.

Soon after the agreement, twelve Radio Amateurs from Reunion Island met to discuss the options for the transmitter. The schedule for the anniversary event was to take place on October 4, 1997 on the 40th anniversary of the launch of the first Sputnik.

To learn more, I contacted Gerard Auvray, F6FAO, Vice President of AMSAT-F. Gerard's immediate response was very informative and a series of e-mail exchanges started between us. He has been most helpful in supplying details for this article. Gerard explained that the model and a spare was being sent to the *Mir* on October 4, 1997 and was scheduled to be released during an EVA on or about October 12th.

As events unfolded, there was a delay from the original release date, and Sputnik 40 was hand-launched from *Mir* by Cosmonaut Pavel Vinogradov during an EVA on November 3, 1997. The new satellite was designated RS-17 once in orbit.

While Sputnik 1 with a solitary signal from space in 1957 captivated the world, Sputnik 40 caused much unparalleled excitement in the Amateur Radio world. A number of us local to the tri-state area of Ohio, Indiana and Kentucky closely followed this satellite including the authors. W8RVH and I became involved in a day-to-day analysis which turned out to be a lot of fun, precipitated many questions, and was a very educational satellite experience. As a result of our experience with Sputnik 40, W8RVH has made an interesting suggestion. The suggestion is the possibility of a similar experiment being launched from one of the many shuttles we send into space. Besides just listening for signals from an Amateur Satellite perhaps it could be arranged to include a repeater the same or similar to that used on the WINDTRAX Balloon Experiments in the Indiana Schools. With such an arrangement, I believe excellent SSTV pictures, for example, could be exchanged as has been very successfully demonstrated on recent WINDTRAX flights. Perhaps some U.S. high school will take this charge?

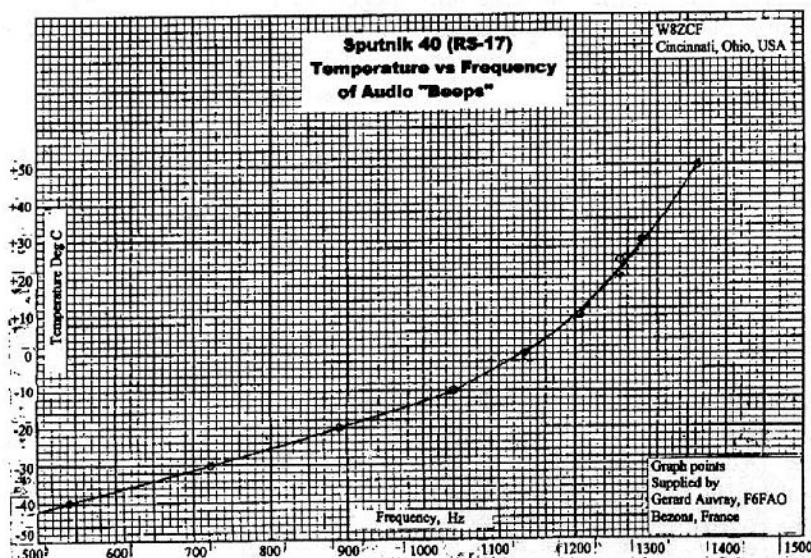


Figure 1. RS-17 Temperature Versus Frequency Conversion Table.

Sputnik 40 Measurements

November 18

Beep's frequencies measured during Nov. 18 (in the night)

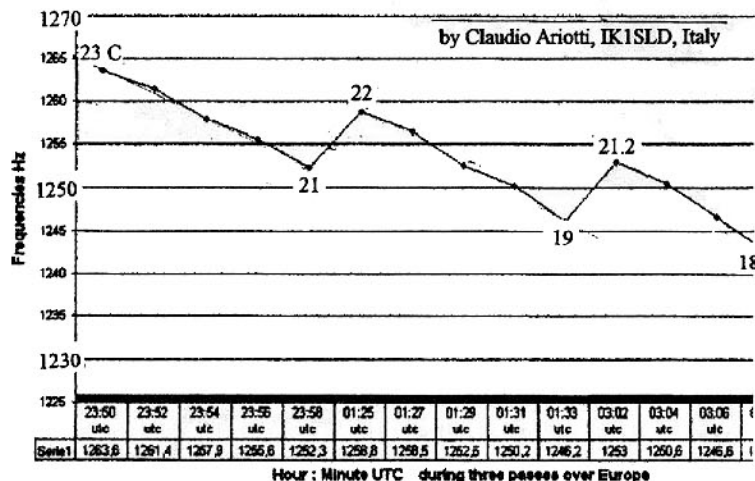


Figure 2. RS-17 Temperature Measurements, November 18, 1997 by Claudio Ariotti, IK1SLD.

Data Analysis

I received excellent signals on the first pass of Sputnik 40 that provided a footprint covering Cincinnati, Ohio. This occurred on November 3, 1997 beginning at 1053 UTC (0553 Local). I copied the entire pass through 1102 UTC with a signal level up to S4 without a preamp on my Yaesu 736R with a FO 22 Yagi (22 elements), having no elevation control. Later, during higher elevation passes, Sputnik 40 signals were easily readable on a Yaesu FT 530 with an 8-inch length antenna.

I became excited about receiving what are basically QRP Amateur class signals from outer space and discussed this with W8RVH during one of our daily early morning ATV exchanges. I was particularly impressed by the signal level and intrigued with an occasional missing beep. We discussed this mystery and conjured up several explanations, such as digital information. After discussing this with several amateurs, including Gerard in France, it was concluded that it was caused by a nulling of the signal due to the respective satellite TX and ground RX antenna orientations. It was sharp enough that it usually affected only one beep. We did find out that Sputnik 40 was transmitting the inside temperature of the satellite and that we could decipher it. As a result, on November 6th, Dick set up equipment to very accurately measure the beep audio frequency which related directly to temperature. With a conversion table supplied by F6FAO, which I reduced to a graph shown as Figure 1, the first frequency measurement was interpreted to be +27° C.

After collecting data for several days, Dick started to observe some very interesting details. When the frequency was noted at AOS and compared to that at LOS, the temperature showed a decrease. At this time and for several days to follow, this was almost always the case. Beginning November 17th, Dick recorded readings at AOS and at LOS. We concluded that if it was cooling off in our area of the Northern Hemisphere, then it must be doing the opposite in the Southern Hemisphere. I appealed several times via AMSAT-BB for someone to come forth with some readings from *Down Under*, but regrettably received no response. We did, however, compare readings with Claudio Ariotti, IK1SLD in Italy (Figure 2) and found his readings were

almost identical to ours, showing a *sawtooth* plot.

At the start Dick and I had discussed that Doppler shift may cause this observation and concluded that it did not present a measurable effect upon the received audio frequency. Since we were consistently receiving negative slope *sawtooth* patterns, we began to challenge our first conclusion about Doppler and began to think we had possibly overlooked something.

As more observers joined our discussion and as we observed additional passes, the average daily temperature did start to increase and observations were made showing nearly constant reading

during a pass or in some cases, a definite increase in the readings from AOS to LOS. During Sputnik's electronic life (November 3 - December 30, 1997), W8RVH recorded over 200 observations. These observations were plotted by Hank Cantrell, W4HTB and are shown as a function of frequency in Figure 3 and temperature in Figure 4. As we began to examine Sputnik 40's orbit using *STSPUS* tracking display, it was noted that the satellite was spending more time in the Sun and as a result, did have a direct correlation to the change in the data which was received. With more complete data, Doppler was ruled out as a measurable amount in the readings.

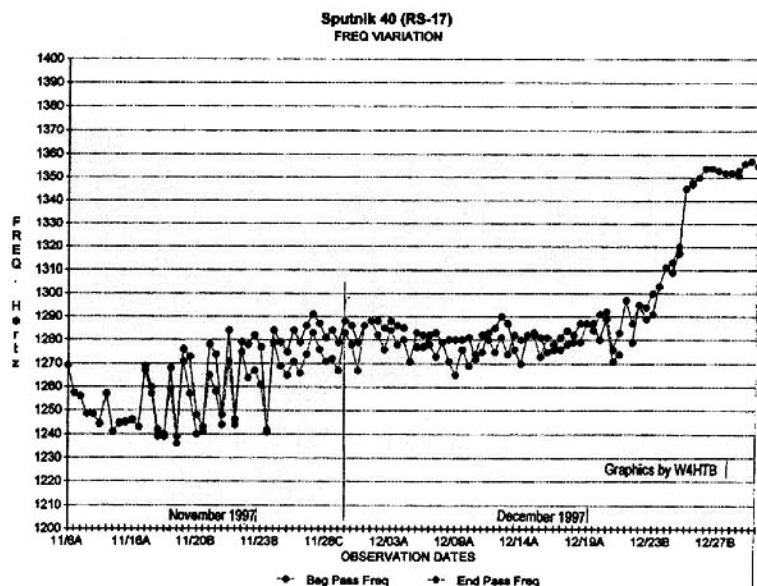


Figure 3. RS-17's tone frequency from November 6 to December 28, 1997.

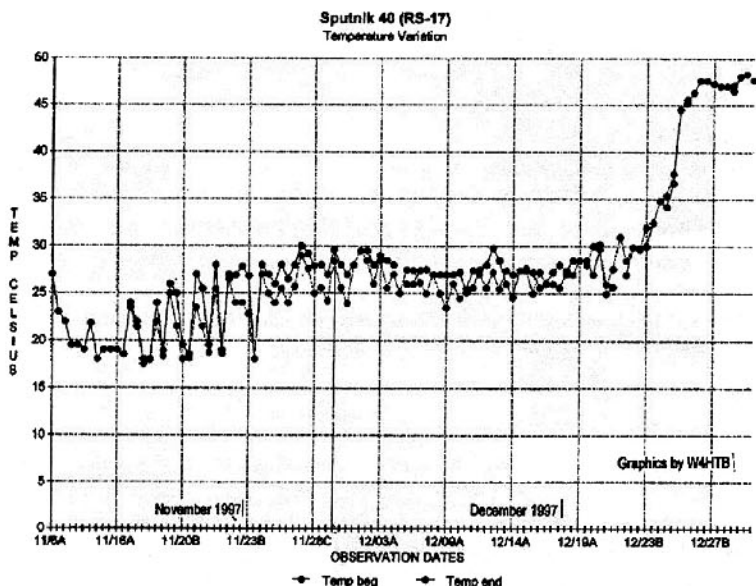


Figure 4. RS-17's temperatures from November 6 to December 28, 1997.

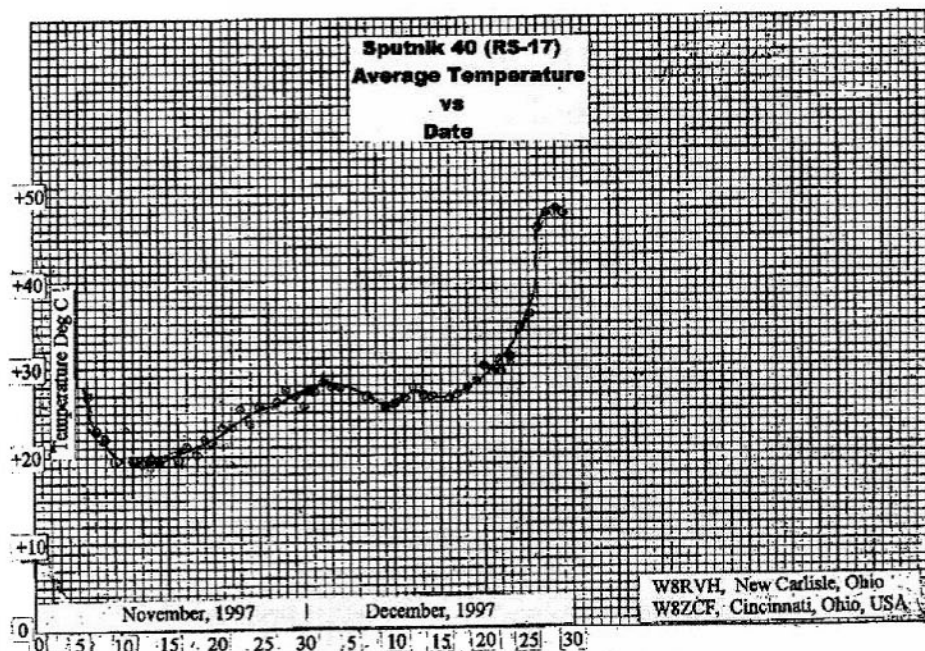


Figure 5. RS-17's average temperature by date.

During the final days of Sputnik 40, we did note that its orbit began to parallel the terminator with more time in the Sun. The temperature *sawtooth* sectors we earlier observed now had either a flat or a positive slope. As the satellite spent even more time in the Sun, the temperature readings of the satellite for our area increased dramatically, soaring from a daily average in the +20°C to +30°C range from November 6 through December 20, 1997 to a high of 48.3° C on December 28, 1997. Figure 5 shows a plot of the average daily temperature. W8RVH's last recording was made December 29, 1997 at 1314 UTC which

indicated a temperature of 47.7° C. While spending more time in the Sun, the depletion of the battery life, and possible battery exothermic heating around the knee of the voltage curve, Sputnik 40 apparently met its electrical demise. Sputnik 40's beeps ceased sometime between an observation made by F6FAO in Paris on December 30, 1997 at 0730 UTC and our attempt to receive a signal in Ohio on December 30, 1997 at 1213 UTC. Both Dick and I continued to listen through other passes, but no further signals were heard. We therefore concluded that Sputnik 40 was *electrically dead*. However this

Figure 6
Sputnik 40 Specifications

Electrical:

- Initial Power Output: 200 mw
- Carrier: FM
- Frequency: Listed at 145.820 MHz but observations showed it appeared to be centered at 145.823 MHz with a +/- 3 kHz Doppler shift during a ten minute pass.
- Audio Beep Frequency: Approximately 1200 to 1300 Hz depending on temperature
- Duty Cycle of Beeps: Approximately 20 percent with a measured repetition rate of 84 to 85 beeps per minute.
- Batteries: 4 Lithium SAFT each at 3.5V at onset providing 14V with a capacity of 27 A/H. (This is the same type of battery as used on the Mars Explorer.)

Mechanical:

- Diameter: 197 mm (7 3/4 inches) sphere
- Antennas: 4 on top hemisphere (very similar to original Sputnik design). Each antenna is 1/4 wave length.
- Antenna Polarization: Circular with no attitude control on the satellite. Ground station signal received from both CCW/CW polarization
- Weight: 3 kg (6.6 lbs)
- Material: Hard aluminum at 15mm wall thickness. Metal layer outside of sphere designed to reflect 40 percent of solar radiation.

satellite is expected to remain a year or more in orbit before disintegration takes place in the Earth's atmosphere.

Frequency Measurement & Equipment Used

The internal temperature of Sputnik 40 was encoded into the audio frequency of the beep signals. This was accomplished using two NE 555's to modulate the oscillator. The final assembly and circuit board are shown as Figures 7 and 8.

To interpret Sputnik 40 temperatures, some method of measuring the frequency of the transmitted beep was required. While expensive laboratory equipment could easily do the job, no such equipment was available. Therefore, an innovative method using Amateur Radio equipment was required.

Since direct readout by a frequency counter failed due to the intermittent nature of the beeps, it was decided to try to synchronize a locally generated audio signal with the beeps and then measure the frequency of the local signal. Aural attempts to establish a zero-beat did not deliver the accuracy believed necessary. As a result, a third method which compared the beep signals and the local audio on an oscilloscope proved to be satisfactory. The classic Lissajous patterns of two frequency comparison allowed easy and steady synchronization of the two audio tones (Figure 9).

The ratio of temperature change to audio frequency was established as approximately 3 to 1, thus temperature accuracy of 1/3°C would be possible if the audio could be resolved to 1 Hz. This became the desired accuracy objective.

Equipment Used

- 2-meter all-mode receiver with an 11 element Yagi antenna
- Stable audio generator
- Frequency counter
- An oscilloscope with vertical and horizontal inputs.

The audio generator chosen was a vacuum tube capacity-type Wein-bridge generator with constant-current stabilization of the oscillating circuit. Further line voltage stabilization was accomplished by use of a Sola constant voltage line transformer. The only

modification needed was to install a small capacity vernier to the audio oscillator which allowed 180° angle rotation to cause a 20 Hz change in audio frequency. This made setting to one Hz easy and practical.

Our frequency counter was a Motorola Model 2006 service monitor. This unit was chosen because the internal time base is an oven controlled 10 MHz crystal which could be adjusted exactly zero beat with WWV, insuring accuracy of count to within one Hz, when the sampling time is set to one second.

The oscilloscope was a 5-inch dual 20 MHz scope, although only one trace was employed using both H and V gain controlled inputs.

All that is required with this type set-up is for an operator to observe the scope while adjusting the frequency vernier to obtain a Lissajous circle. After holding this pattern steady for one second or more, a reading can be made on the incoming frequency to within 1 Hz. It was surprising to observe that these circle patterns were easily discernable well down into the noise.

Many Sputnik 40 observations were recorded from AOS to LOS. The actual frequencies measured between 1250 and 1350 Hz with 1 Hz incremental changes being readily detectable.

Acknowledgements

Congratulations are in order for all those who financially contributed to this satellite and to the Russian and French high school students who so successfully assembled the working model. Perhaps with this experience some of them will go on to become Amateur Radio operators or Astronauts. We learned that the Russian high school students initiated the Sputnik 40 idea. They, however, realized the cost and work necessary; therefore, presented the idea to the French who accepted and became partners in this historic celebration. We also learned that many French schools competed to build the transmitter with the winner selected as Reydelle School on La Reunion Island.

The authors wish to say thanks for the opportunity to share our findings. We had a lot of fun and learned a lot about satellites. Every AMSAT member should try this type experiment sometime! ■

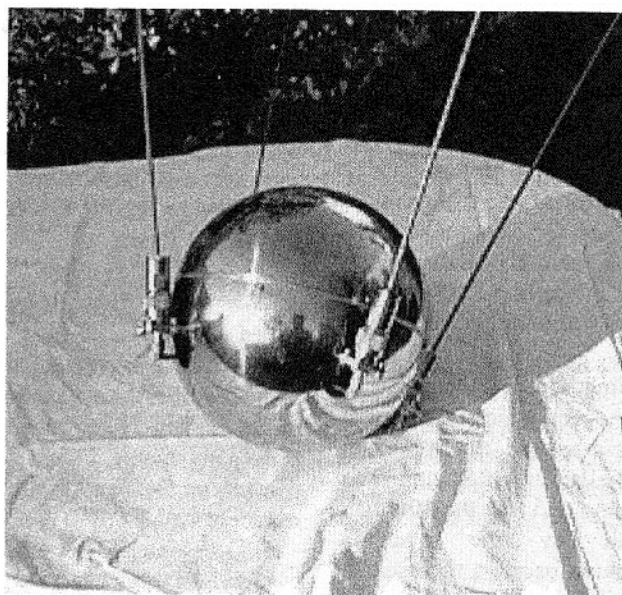


Figure 7. Final Assembly of RS-17— Ready for Launch!

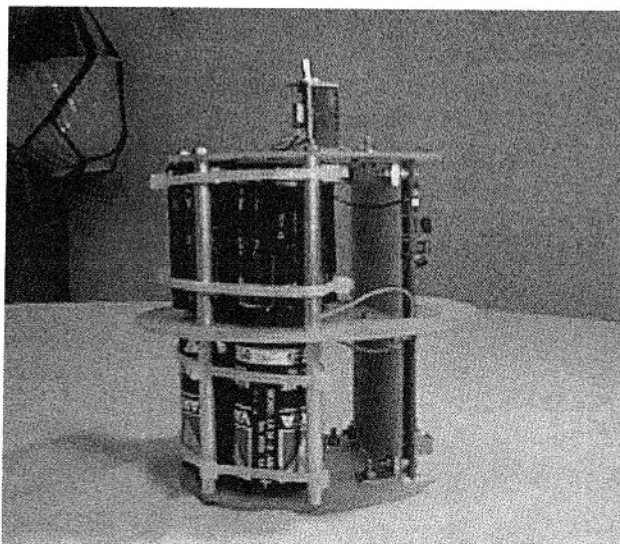


Figure 8. RS-17's circuit board in holding frame with batteries.

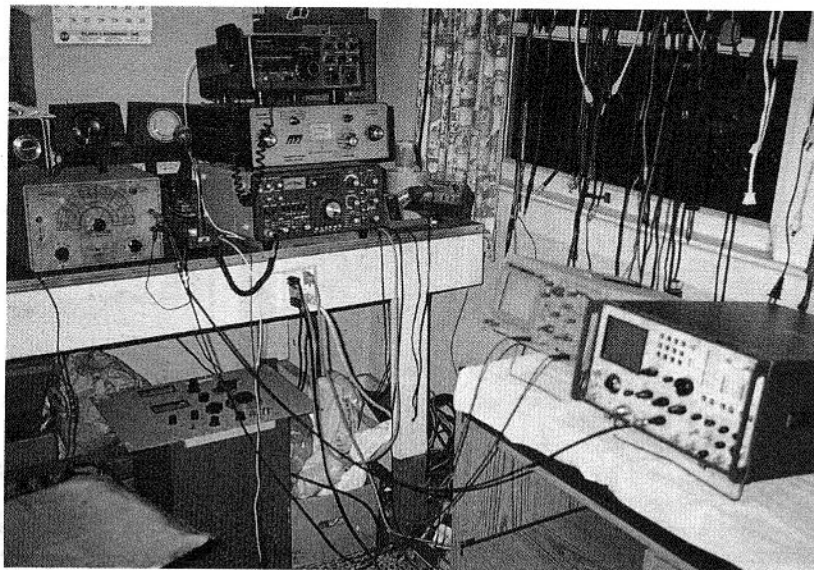


Figure 9. W8RVH setup for Sputnik 40 frequency tone measurements.

The Sputnik Award

John Heath, G7HIA, g7hia@amsat.org

If you worked our Sputnik 40th Anniversary Special Event Station, thanks for taking part! If you missed it, then make a note in your diary for October 4, 1998 when, God willing, we will be on air on the 41st Anniversary of the launch of Sputnik 1, the world's first artificial Earth satellite.

Robert Turlington, G8ATE and I teamed up for the event, which was a direct result of Robert's remark that the 40th anniversary of the launch of Sputnik was rapidly approaching and that the 30th had gone unnoticed by the AMSAT community. Looking back on the event it was a remarkable experience in many ways.

We exchanged packet and fax messages with Leonid Labutin, UA3CR in Moscow and received enthusiastic support for the event and a his commitment to come on air with the rare Ground Station call RS3A,

both on phone and CW. We made the Sputnik Award into a fund raising event to help the Russian RS ground station by supplying an AZ/EL rotator and antennas for 2m and 70cms.

We also communicated by fax with Hideo Ono, JA1BU at JARL and were rewarded with agreement to switch FO-29 to mode JA for the event. This was a superb piece of ham radio cooperation which proved invaluable. In fact, over half of our contacts on October 4th were made on that excellent bird.

AMSAT-UK permitted us to use their call GX0AUK so that we could be on air with two calls MX1ASE and GX0AUK. Meanwhile, Leo UA3CR sent us a Space Calendar presented to him by *Mir* cosmonauts. From this we extracted the pictures used on the 8"x11" award certificate (Figure 1). Also, Pat Gowen, G3IOR loaned us his original Sputnik 1 QSL card so that we could scan the image for use on our QSL card (Figure 2). It was a privilege to handle such a rare and historic item.

Lots of activity was stimulated on the analog LEO's and we had a lot of fun. Over 300 contacts were made with over 200

individual Radio Amateurs. A total of 22 countries worked; all on the LEO's and from our modest low power stations. Ib Christoffersen, OZ1MY contacted us on behalf of AMSAT-OZ and offered to help us with any shortfall in the fund raising. This was certainly a magnificent gesture from AMSAT-OZ group and shows the great spirit there is in the hobby. (This extra help ensured that we met our target.) Many of the award applications contained personal notes recalling happy memories of receiving the first signals from Sputnik 1 some forty years ago.

What Did We Learn From the Event?

Where we went wrong: Certainly lack of publicity as not everyone has packet or Internet access. Also, information has to get to magazines, and AMSAT groups sooner. *Publicity for the 1998 event starts here!*

The organization, paperwork, and follow up was more involved than we had anticipated. However, the pleasure and satisfaction of putting something back into the hobby outweighs all the hard work.

This is a truly a unique hobby! Where else could an event be conceived and organized that involved participation and co-operation from Russia, Japan, AMSAT-UK, AMSAT-OZ and participants from 22 countries who came on air and enjoyed the event. ■



Figure 1. Sputnik Anniversary Award.

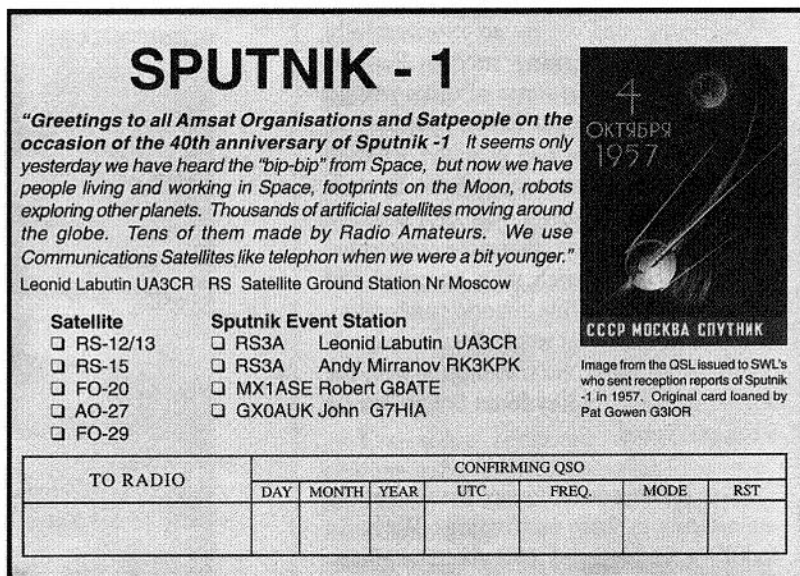


Figure 2. Sputnik Anniversary QSL Card.

A Candidate Orbit for Future AMSAT Spacecraft

Ken Ernandes, N2WWD

n2wwd@amsat.org

This paper analyzes the utility of circular low-inclination, medium-altitude orbits for Amateur Radio spacecraft. This orbit type provides much of the coverage footprint realized from either a geosynchronous orbit or apogee of a high-eccentricity (Molniya) orbit. Low inclination, medium altitude orbits also provide all-longitude access, with long coverage windows and with revisits on every revolution. As such, almost every potential user has equitable coverage with just a single satellite on orbit. More importantly, additional satellites can be added in a coordinated fashion, providing complementary access. Ultimately, medium altitude orbits can form a three-satellite constellation, yielding 24-hour coverage to most users.

This paper is a follow-on to Bill Tynan, W3XO's "A Possible Phase 3D Follow-on Project," presented at the 1996 AMSAT Symposium and reprinted in *The AMSAT Journal* (see refs. 1 and 2). The purpose is finding a desirable orbit providing good coverage to the potential users. The most important consideration is that the orbit's coverage must allow for a three-satellite constellation that provides continuous (or nearly continuous) coverage for the most populated areas of the Earth's surface.

Whether or not an orbit is otherwise considered desirable is subjective, based on the Orbital Design Goals (discussed in the next section). These goals are my opinion of what the AMSAT membership wants, based in part on the content of messages posted to the AMSAT-BB Internet mailing list. As such, they are subject to change based on further inputs from the AMSAT membership.

Orbital Design Goals

The following orbital design goals provide a basis for selecting the candidate orbit type presented in this paper. The design goals are:

- Provide an orbit that supports the three-satellite constellation, providing continuous coverage of the populated regions of the Earth's surface.
- Provide a large footprint, with Earth surface coverage comparable to a Phase 3 satellite at apogee.

- Select an orbit that can be achieved from an Ariane (or other available) booster, and achievable within the delta-V budget of a Phase 3 spacecraft.
- Reduce free-space signal path loss, choosing the lowest feasible altitude that supports the other goals.
- Select an orbit that is generally useful with the launch of the first satellite. As such, provide equitable coverage across all longitudes, preferably with a short revisit schedule. (A short revisit schedule would have contact times distributed over a station's 24-hour local schedule within the span of a week.)
- Select an orbit with minimal perturbative effects to reduce or eliminate satellite stationkeeping requirements.

Candidate Orbit Types

The preliminary spacecraft design proposed by W3XO is somewhat flexible as to the type of orbits in which it could effectively operate. Three orbit types were initially considered: the Geostationary Earth Orbit (GEO), the highly elliptical or Molniya orbit (used by the Phase 3 spacecraft), and the medium altitude orbit. After analyzing these three orbit types, I concluded that the medium-altitude orbit offers the best overall balance of advantages versus disadvantages for the spacecraft system proposed by W3XO. In the next few sections, I shall address each type, providing the reasons why I consider the medium altitude orbit the best choice.

The Geostationary Orbit

The attractions to the GEO are that ground stations orient their antennas in a constant direction and there is no Doppler shift. However, these attributes have made this orbit type so popular that the *geosynchronous belt* is very crowded with satellites. Therefore, it would be difficult for AMSAT to find three available positions 120° apart in the most *prime real estate* in space.

Furthermore, GEO orbits require periodic stationkeeping maneuvers. These maneuvers are needed to correct orbital changes caused by the Sun and Moon and to prevent collisions with neighboring GEO satellites.

Because of their altitude, GEO orbits are the least efficient (of the three candidate

choices) for attitude control magnetorquing against the Earth's magnetic field.

The fact that a GEO orbit remains fixed relative to the Earth's surface also has disadvantages for amateur radio communications. A GEO, by its nature provides no variety in satellite coverage. Therefore participation could only be expected from ground stations that lie well within the footprint. Furthermore, the lack of DX variety may somewhat dampen the enthusiasm of stations that are within the footprint.

Excluded stations could only be counted on for participation in building new satellites, augmenting the constellation (and providing coverage to their area).

The Molniya Orbit

The highly-elliptical Molniya was an excellent choice for the AMSAT Phase 3 spacecraft. This orbit type offers a large coverage footprint in an orbit that is readily achievable from a Geosynchronous Transfer Orbit (GTO). Because of the physics of orbital motion, a satellite in an elliptical orbit has a long *hang time* in the higher altitude portions of the orbit. The Molniya orbit also allows for very efficient attitude control magnetorquing in the lower altitude portions of the orbit.

One disadvantage to the Molniya orbit is that it can be very sensitive to the gravitational perturbations imparted by the Sun and the Moon. The most obvious illustration of these effects is the demise of AMSAT OSCAR 13 (AO-13). Extensive planning is required for orbital adjustment maneuvers that ensure a Molniya orbit will not suffer an untimely orbital decay similar to that of AO-13. Furthermore, it can take more than a year to accomplish the actual sequence necessary to establish a survivable Molniya orbit.

A significant disadvantage of the Molniya orbit, specific to W3XO's proposed system design, is the difficulty in providing continuous coverage. Because of the small footprint when the satellite is at perigee, it is likely that six spacecraft would be needed to satisfy the 24-hour coverage requirement.

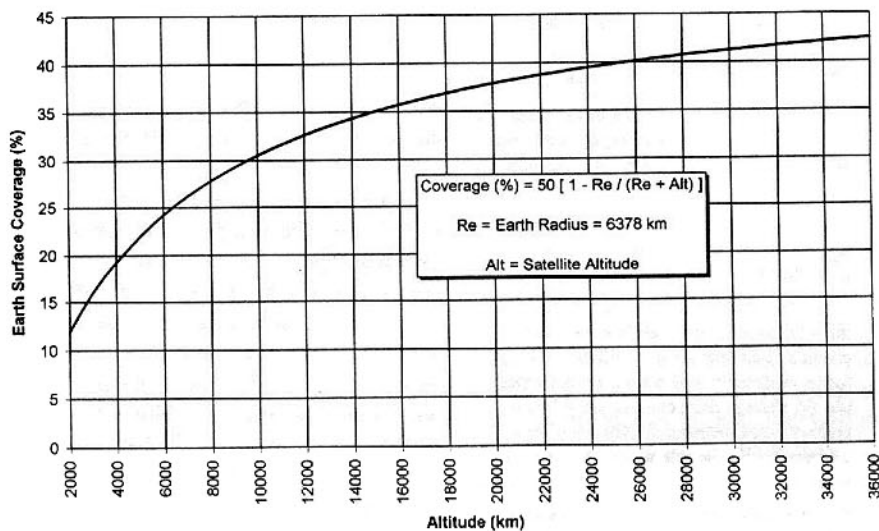


Figure 1. Earth Surface Footprint Coverage as a Function of Altitude

Furthermore, the electronic feed horn switching proposed by W3XO would be more complex for a Molniya orbit. Switching would need to occur at varying rates to compensate for varying orbital rates between apogee and perigee.

Medium Altitude Circular Orbits

This paper proposes the use of low-inclination, medium-altitude circular orbits. The medium altitude is suggested as a balance between a large footprint (goal #2) and minimizing both signal path loss and below-the-horizon revisit intervals (goals #4 and #5 respectively). Circular orbits are suggested since they allow a straightforward continuous coverage constellation design.

The largest gains in Earth surface coverage occur as altitude increases in the range from Low Earth Orbit (LEO) to about a 24000 km altitude as illustrated in Figure 1. Increases in altitude above 24000 km provide marginal returns in terms of additional footprint area. The LEO to 24000

km range may be further narrowed since it is impossible to get full coverage from a three-satellite constellation with the altitude below two Earth radii (approximately 12800 km). A 14000 km altitude is suggested as a practical minimum since most coverage gaps are reduced or eliminated at this altitude. Therefore, the suggested altitude range is 14000 to 24000 km, providing an 8 to 14 hour orbital period.

The other advantage of the medium altitude orbit is that the first satellite orbited provides balanced coverage of the populated areas of the Earth. This satisfies both the desire for DX variety and provides equitable access to all longitudes. Augmenting the constellation with a second and third satellite would likewise be beneficial to all, ultimately closing most or all of the coverage gaps.

Constellation Arrangement

Orbital design to get essentially 24-hour global coverage is relatively simple for a

medium altitude circular orbit. The method published by J.G. Walker (see ref. 3) and later generalized by A.H. Ballard (see ref. 4) provides an orderly transition of footprint coverage from one satellite to the next.

The essence of a Walker or *Rosette* constellation is providing equal spacing of orbital planes, allowing sufficient overlap at the Equator. Satellite phasing between adjacent orbital planes is selected to coordinate replacement of one satellite footprint with the next. Orbital inclination is selected to provide coverage overlap at the North and South Poles or the highest latitude in which complete coverage is required.

The specific orbit design for the medium altitude amateur radio constellation places the three-satellites in unique orbital planes separated by 120°. Each satellite is also phased 120° along-track relative to its neighbors. A 10° inclination is used since it provides reasonably high latitude coverage and is standard for an Ariane 5 GTO. Sample constellation Keplerian elements are provided in Table 1 for visualization. Figure 2 provides a *snapshot* of the satellite coverage footprints for this constellation.

The middle satellite in the footprint plot is nearly at its lowest latitude. This snapshot was selected for the figure to show that there is an approximately 55° latitude threshold for 24-hour coverage. The footprint also shows partial coverage up to a maximum 85° latitude.

Note that while the 120° spacing between adjacent orbital planes is ideal, the relatively low 10° inclination makes this a non-sensitive (or low importance) characteristic of the constellation. Therefore, if a trade-off is required to maneuver a new satellite into the constellation, achieving the proper phasing takes priority over getting the exact orbital plane. This provides flexibility when adding satellites to the constellation.

Path Loss Versus Altitude

Path loss increases with the square of the distance from the satellite to the ground station. At medium altitudes a relatively small decrease in distance can add a few decibels (dB) to the signal strength. Figure 3 plots the relative loss (independent of

Table 1

Sample Keplerian Elements for a 19000 km Altitude Rosette Constellation

Satellite:	AMS-1	AMS-2	AMS-3
Catalog Number	:99991	99992	99993
Epoch Time	:97200.5	97200.5	97200.5
Element Set:	1	1	1
Inclination:	10.0°	10.0°	10.0°
RA of Node:	0.0°	120.0°	240.0°
Eccentricity:	0.00001	0.00001	0.00001
Arg. of Perigee:	0.0°	0.0°	0.0°
Mean Anomaly:	0.0°	120.0°	240.0°
Mean Motion (rev/day):	2.14740118	2.14740118	2.14740118
Decay Rate (rev/day ²):	0.0	0.0	0.0
Epoch Rev:	1	1	1

frequency) for the longest path (at horizon) and the shortest path (directly overhead) versus altitude. The actual path loss for any particular frequency is the curve value plus a $20 \log f$ offset (see ref. 5). The relative path loss is sufficient to evaluate path loss differences between two different orbital altitudes. (Note that there is typically 5 dB of path loss difference between a satellite at a 19000 km altitude and one that is at geosynchronous altitude.)

Revisit Interval Versus Altitude

It is unlikely that AMSAT would be able to build and launch a three-satellite medium-altitude constellation in a short time. A realistic scenario is to populate the constellation by building and launching one satellite at a time with some overlap. Given these circumstances, it is important that the first satellite in orbit provide substantial access to as many AMSAT members as possible (consistent with goal #5).

As pointed out earlier, a GEO orbit provides infinitely long contact windows but no coverage variety. Likewise, an orbit at near geosynchronous altitude would provide very long contact windows with coverage varying very slowly. This orbit type also has extremely long intervals between revisits once the satellite footprint drifts away from a ground station. The long wait between satellite revisits would be undesirable to most.

A satellite in a medium altitude circular orbit with a low inclination revisits most ground stations every revolution. (Stations at very high latitudes are the exception.) The coverage revisit interval is the difference between the orbital period and the average contact window duration. Figure 4 provides a sample contact window for a single satellite at a 19000 km altitude. (These contact windows were computed for a station at approximately 41° North latitude.)

If possible, revisit intervals should begin and end at varying local times within a week (consistent with goal #5). This is best accomplished by choosing an orbit that does not closely repeat its ground track within a week. (There should not be an exact integer number of revolutions for one day — the sample 19000 km constellation repeats in seven days.) Such a lack of *resonance* depends primarily on orbital altitude.

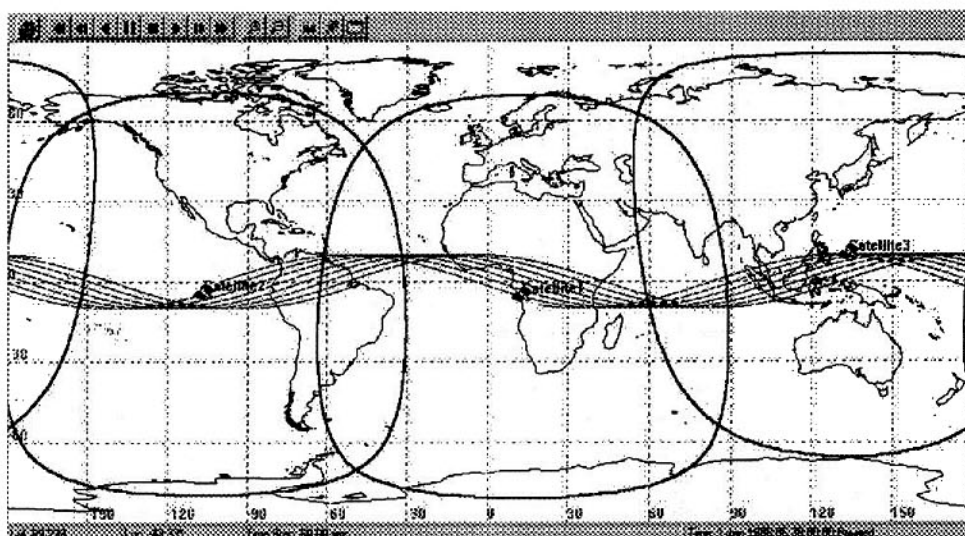


Figure 2. Medium Altitude Rosette Constellation Footprint Snapshot

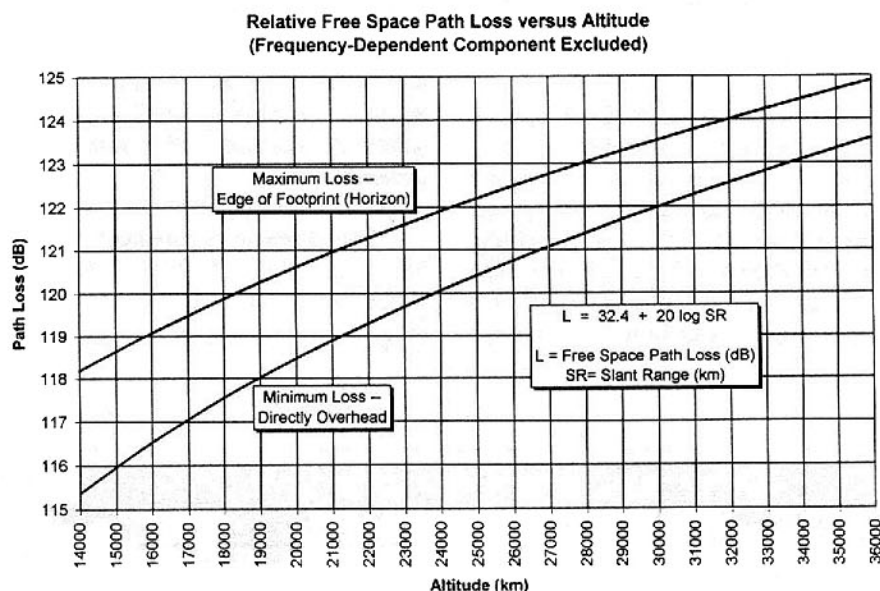


Figure 3. Relative Free-Space Path Loss as a Function of Altitude

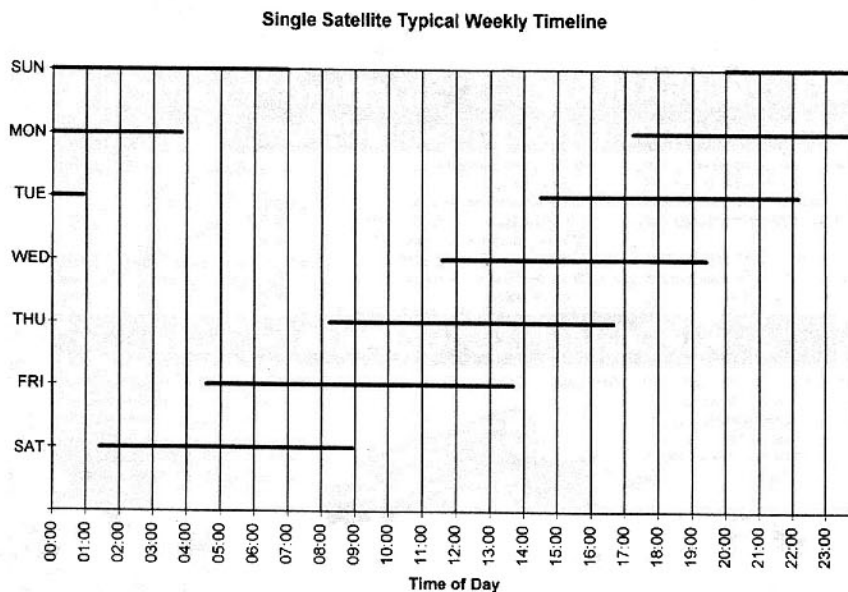


Figure 4. Sample Weekly Schedule for a Single 19000 km Altitude Satellite

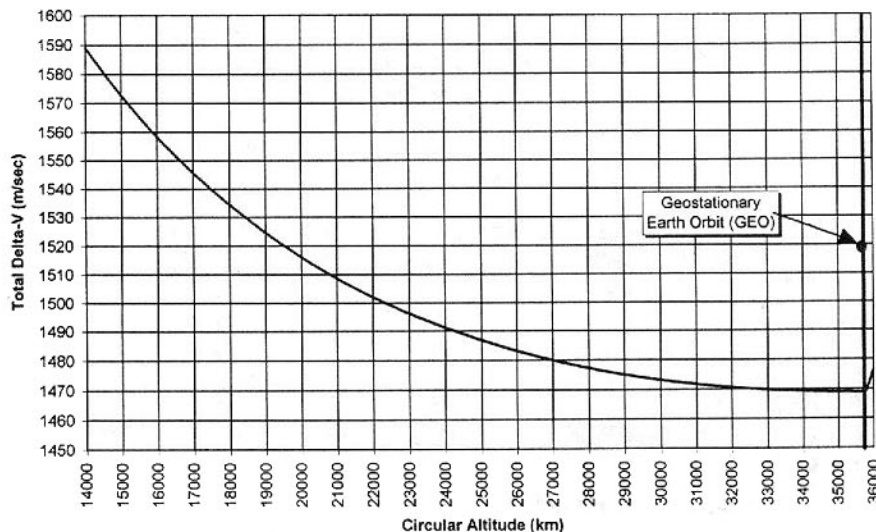


Figure 5. Delta-V Requirements from an Ariane 5 GTO to a Circular Orbit

Stationkeeping Requirements

Unlike GEO orbits, medium altitude orbits fly through a relatively sparsely populated region of space. Stationkeeping is only necessary to maintain the correct phasing between the satellites, preserving the constellation's coordinated coverage replacement. Loss of a satellite's stationkeeping capability (through

propellant exhaustion or system failure) will result in an eventual loss of constellation phasing. Satellite replacement would be necessary to restore 24-hour coverage.

Stationkeeping requirements vary with orbital altitude. It is highly desirable to choose an altitude that provides a stable orbit. A stable orbit minimizes both the

frequency of stationkeeping orbital adjustments and the amount of propellant consumption when orbital adjustments are needed. Choosing the optimum altitude for stationkeeping is likely to be a complicated analysis, so it has been deferred to a later study.

GTO To Final Circular Orbit

An important part of evaluating a candidate orbit is identifying a feasible way of getting the spacecraft to that orbit. When analyzing feasibility, one must consider the velocity change (delta-V) required to achieve the orbit. This defines the amount of propellant necessary to go from the orbit provided by the booster to the desired orbit. Overly complicated or risky orbital transfer profiles should be avoided.

Since AMSAT has enjoyed good success in manifesting its spacecraft on European Space Agency (ESA) Ariane boosters, the sample mission profile is designed using this type of launch. More specifically, the mission profile assumes a GTO. An Ariane 5 GTO has a 280 km perigee, a 35786 km apogee, and a 10° inclination (see ref. 6).

A medium altitude circular orbit can be achieved from a GTO using two thruster firings. The first thruster firing is done at apogee of the GTO, raising perigee to the [final] circular orbital altitude. The second thruster firing is done at perigee, lowering apogee and establishing the circular orbit. Figure 5 illustrates the delta-V required for various circular altitudes. Note that because of the high apogee of the GTO, the higher altitude orbits are more economical from a delta-V standpoint than are lower altitude orbits. Note also that the inclination change that brings the GEO inclination down to 0° increases the delta-V requirement for this orbit type as indicated on the chart. In actual practice, a non-zero inclination (such as 5°) would be selected. The delta-V requirement to establish a geosynchronous orbit with a 5° inclination from an Ariane GTO is approximately 1482 m/sec.

The first satellite can be brought on station relatively quickly (days or weeks) after insertion into the GTO. Subsequent satellites require more time since we will expect our satellite to be a secondary payload for the launch. Since the primary payload generally specifies the launch window, we will accept whatever orbital

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plane is established by the GTO. Time will be required for the GTO's orbital plane to drift relative to the other satellite(s) in the constellation until the correct arrangement occurs. The timing of the burns will then be selected to achieve the proper phasing with the constellation.

Practicality may require using multiple smaller burns to accommodate thruster constraints and achieve the correct constellation phasing in a more timely fashion.

While the spacecraft proposed by W3XO is only preliminary, the satellites could be designed to operate while in the GTO. This provides useful capability during the *waiting* interval before the satellite can be maneuvered into its specified position in the constellation.

Summary and Conclusions

A low-inclination, medium-altitude circular orbit readily accommodates a three-satellite Rosette Constellation, providing continuous coverage to all but high latitude users. For the 19000 km example, the constellation gives continuous coverage for stations at latitudes within

about 55° of the equator. Higher latitude stations begin to develop coverage gaps that increase in duration and frequency as you approach either pole. (No coverage is available for the example constellation for stations with latitudes greater than 85°.)

The proposed orbit provides desirable coverage with reasonably equitable access as formation of the constellation begins with the orbiting of the first and second satellites. The orbits, including constellation phasing arrangements, are achievable from an Ariane 5 GTO. The 19000 km altitude constellation was selected as an example that satisfied the defined goals. However, the stationkeeping requirements for a constellation at this altitude were not analyzed. Should AMSAT decide to pursue use of this orbit for a Phase 3D follow-on project, final constellation design will require further analysis of latitude coverage and stationkeeping requirements to determine the best altitude.

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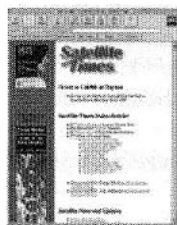
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- [6] *International Reference Guide to Space Launch Systems, Second Edition*, Steven J. Isakowitz, AIAA, 1991, ISBN 1-56347-129-9. ■



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An EZ-Sat Proposal

Frederick J. Winter, N2XOU, fwinter@ix.netcom.com
Ken Erlandes, N2WWD, n2wwd@amsat.org

This paper outlines plans for an EZ-Sat project. This satellite would provide additional entry-level amateur communications capability, using some of the most commonly-owned Amateur Radio equipment. This project benefits the AMSAT community by adding a new satellite that can be operated with modest equipment and from a portable or mobile station. The design, construction, and operation of such a system provides a practical telecommunications curricula supplement to several undergraduate-level programs. The ultimate project goal is to develop a series of simple, yet effective spacecraft carrying Amateur Radio communications payloads.

This EZ-Sat project intends to provide a basic orbiting amateur communications capability from a spacecraft built and controlled by undergraduate students. The educational benefits are that an amateur satellite project with real technical obstacles can provide the students with a practical and interesting application of classroom material. AMSAT benefits by getting a new entry-level satellite with potential to spur new interest in amateur satellite communications.

The authors were first introduced by Dick Knadle K2RIW, following Fred Winter's, N2XOU successful bid for a scheduled SAREX contact at Suffolk County Community College, Long Island, New York. An excellent working relationship developed between N2XOU and N2WWD while planning and coordinating this SAREX contact during STS-71, the first docking of the Space Shuttle *Atlantis* with the *Mir* Space Station. The smooth execution in which all twenty local students spoke with *Atlantis* Commander Hoot Gibson impressed Suffolk Community College President, John Cooper, enough to offer continued support for incorporating other amateur space communications projects in the school's technical curricula.

Suffolk County Community College now has a permanent satellite communications station and is assembling the equipment necessary to support SEDSAT command and control. The

EZ-sat project provides the real technical challenges that match the subject matter covered in the communications technology syllabus.

Goals

The primary goal is to build and orbit a working amateur communications spacecraft. We believe a new *EZ-Sat* accessible with common and affordable amateur radio equipment would be a welcome addition to the amateur satellite fleet.

Other important goals include:

- The spacecraft must be simple in design and construction, reproducible by undergraduate students in the community college environment.
- Develop a base of expertise in spacecraft design, analysis, construction, and project coordination and management.
- Develop a satellite Command and Control (C²) infrastructure capable of handling multiple satellites.
- Maximize the applicability of these projects to the telecommunications and other curricula at the college.
- Make the experience rewarding (some students might actually enjoy their lab projects).

Conceptual Design

We propose a single frequency satellite using a communications payload with a 2 meter FM uplink and a 10 meter SSB downlink. The reasons we chose this frequency arrangement are:

- The popularity of 2 meter FM amateur radio transmitting equipment.
- Availability of 10 meter SSB receiving equipment in general HF transceivers, 10 meter single-band transceivers, and communications receivers.
- Low satellite power drain using SSB transmit.
- Manageable antenna sizes.
- Relatively low Doppler frequency shift simplifies operation.
- Usability by most amateur radio license classes including the US no-code Technician license.

We also propose the use of a small, inexpensive microsat spaceframe, using

passive thermal and attitude control designs.

This satellite will operate in a Low Earth Orbit (LEO), but will be capable of operating effectively in virtually any orbit. Because of the single frequency operation, the satellite's transmitted energy will be concentrated on a single, communications channel with a relatively strong downlink signal.

The spacecraft's 2 meter FM receiver will be designed to be as sensitive as possible; analysis of the link margin will determine the exact sensitivity goal for the receiver. However, the initial goal is to allow for enough margin for an uplink signal of 5 watts of ERP, assuming a satellite elevation of 30° and a 1000 km orbital altitude. Because of this sensitivity and the popularity of the FM band, the receiver will require sharp filters to reject adjacent signals and will likely use CTCSS tone squelch to reject on-frequency signals not intended for the spacecraft.

Technical Support Requested

We are seeking technical support in two basic areas: a basic microsat design and methodization of spacecraft assembly.

A basic microsat design would, at minimum, provide an example that could be adapted as necessary to accommodate our particular spacecraft. This would include any details on the spacecraft's Command and Control (C²) design. Our ultimate hope is that few, if any, modifications would be necessary. Toward this end, the AMSAT microsat is a most welcome option.

For spacecraft assembly, we are seeking advice on construction methods for both mechanical and electronic assemblies. Some specific areas include the choice and application of thermal coatings and solar arrays as well as the use of epoxies or other stiffeners for electronic assemblies to ensure they survive the launch or other mission-related mechanical stresses.

Other Requested Support

One of the most important considerations is finding a ride to orbit. We

are very interested in learning the process by which amateur radio spacecraft get a "free ride" as ballast on space launches. Specific individuals to contact and any advice in this area would also be welcome.

Another important area in which we seek AMSAT expertise in securing donations of *scrap* material such as solar cells and storage batteries for the construction of the spacecraft. Again, names of specific individuals to contact would be very helpful.

Summary

The ever more fascinating world of satellites is at our doorstep. We wish to

invite it into the guest room for a while in order to experience its many facets much like that of a fine diamond. We seek guidance from the experts and have determined them to be the professionals at AMSAT.

About the Authors

Frederick J. Winter, Ph.D., holds a Technician Class license and has enjoyed a career as an Engineering Consultant, a Microwave Communications Engineer, and most recently a Professor of Engineering Science, Electrical Technology, and Telecommunications. Teaching at the undergraduate level at Suffolk Community College and at the

graduate level at Polytechnic University (formerly "Brooklyn Poly") provides Mr. Winter with students who are interested in advanced technical projects.

Kenneth J. Ernandes, BS, ME, holds an Extra class license and was formerly a USAF Captain, and Orbital Analyst Instructor for NORAD/ Space Command. Ken received air combat maneuvering training in the F-15 Eagle. Achieving Scholarship status, Mr. Ernandes has enjoyed a career as an Engineer and a Satellite specialist who is well known to AMSAT as well as NASA. Mr. Ernandes has computed orbits for Amateur Spacecraft and is a recognized expert in orbital mechanics. ■

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AMSAT is pleased to announce the arrival of the NEW Satellite Handbook by Dr. Martin Davidoff, K2UBC. This brand new edition contains everything you need to know on operating, antennas, software, Internet sites, profiles of all the active satellites and more. The book is 376 pages and the postpaid cost is: \$25 in the US; \$30 in Canada; \$35 in South America and Europe; \$40 elsewhere. To order, call AMSAT-NA at 301-589-6062. You can also fax your order to 301-608-3410 or e-mail martha@amsat.org.

Call for Papers for the AMSAT-NA 16th Space Symposium and AMSAT Annual Meeting

The 16th Space Symposium and AMSAT Annual Meeting will be held October 16-18 1998 at the Park Inn International in Vicksburg Mississippi. This is the first call to authors who wish to present papers at the Symposium and that will be printed in the Proceedings. The subject matter of the papers should be topics of interest to the amateur radio satellite service. Key dates in calling for and submitting papers are:

- One page abstracts are due no later than June 1, 1998,
- Authors will be advised by e-mail or postal mail shortly after June 15, 1998 regarding whether their paper has been accepted or not,
- Camera ready copy of accepted papers is due no later than August 15, 1998. Papers will only be superficially edited and will generally be printed as submitted. Authors are requested to provide an electronic file preferably in any version of MS Word or WordPerfect in the event a *major disaster* is spotted and can be corrected at the last minute.

Abstracts can be sent to w5xx@magnolia.net or to Malcolm Keown, W5XX, 14 Lake Circle Drive, Vicksburg, MS 39180. If you do send an abstract by e-mail, it might be wise to send a follow-up postal-mail copy since things do get lost in cyberspace.

Proceedings of the Symposium will be printed by the ARRL and made available at and after the meeting. Also, if you do not wish to present a paper, but have a topic of interest, please submit the topic and *perhaps* arrangements can be made for a presentation.

Information regarding Vicksburg area attractions and details on arrangements for the 16th Space Symposium and AMSAT Annual Meeting can be found elsewhere in this and future issues and at <http://pages.prodigy.com/DXHF93A>.

OSCAR SKN '98 Results

Thanks to all who participated in AMSAT-NA's OSCAR SKN '98. Although activity was down from prior years due to the loss of RS-10, the temporary loss of Mode K on RS-12 and the unfavorable position of AO-10, a good time was had by those who took part.

Once again our first-place winner was Rusty, NM1K, who received five separate nominations. Two more 1998 winners also had been nominated in previous years: G3RWL and W1NU. Joining the winners' circle for the first time in 1998 were AG2R, K4IPH and VE5SWL. Heartiest congratulations to all. [continued on page 31]

Delaware Rockets for Schools Project

Dr. Sam Guccione, K3BY

Delaware Technical & Community College, Dover, DE

I have been associated with a statewide group called the Delaware Aerospace Education Foundation (DASEF). The major aim of DASEF is to develop student's interest in science, math and technology using space as a unifying theme. The executive director of DASEF is Dr. Stephanie Wright. Through a series of summer camps and workshops throughout the year, Dr. Wright has been extremely successful in developing this interest in school children and their parents. I had talked to Dr. Wright several times about doing a helium scientific balloon flight as a part of her programs. Dr. Wright went one giant leap further. She convinced me to be involved in a sub-orbital rocket launch. As a former aerospace engineer, I leaped (or would that be rocketed) at this chance.

Dr. Wright joined a group called Rockets for Schools who launch sounding rockets for educational purposes. Dr. Wright negotiated for the purchase of the rocket and a launch date of May 11, 1997.

The rocket launch would be for educational purposes including the assembly and testing of low cost technology to explore near space. In addition, collection of scientific data would be a goal. Many other issues besides the two listed here resulted from the project as well. For example, the environmental impact of the launch on Piping Plover's (a small coastal bird that is an endangered species) was a major consideration. Several school groups explored this issue.

school students and teachers could become involved was developed. Through Dr. Wright's extensive connection to the primary and secondary school system, the brochure was mailed to every school teacher in the state of Delaware. She and I presented the project to various teacher workshops. Interest began to build.

The design of the project was to have launches of a: Super Loki sub-orbital rocket, helium scientific balloon and number of small amateur rockets and balloons. School students from grade 6 through high school were encouraged to participate.

My part of the project was as payload manager. Payloads were designed and constructed by my students for the scientific balloon and the Super Loki rocket. Attempts were made involve high school teachers and students.

Figure 1 shows the payload for the balloon. A polyfoam minnow bucket housed an ATV transmitter with color camera and a MIM/MIC/GPS20 based GPS transmitter. The GPS antenna was a simple quarter wave whip sticking out of the top of the lid. The ATV antenna was a horizontal half-wave dipole. This later proved to be one of the several engineering design mistakes that were made during this project. Due to the use of this horizontal antenna, the picture would be lost whenever the end of the dipole pointed at the ground station antenna. This happened fairly often as the payload rotated with the wind.

In retrospect, we should have used a vertical or a horizontal such as a little wheel. Nevertheless, P5 quality pictures were achieved for a significant part of the time. We were able to pick out the wake of ships with our setup. This was quite remarkable to me since we used an inexpensive color camera and a transmitter power level of only two watts at best.

The total weight of the payload was about two pounds. The Totex balloon, shown in Figure 2, was calculated to lift this weight at 1000 feet per minute. A takedown device was included with a timer. The plan was to burst the balloon at one hour after launch. It was expected that the parachute would let the payload fall at about 1000 feet per minute. A total flight time of about two hours was planned. This would put the balloon on the ground before the 2 p.m. Super Loki launch. It was estimated that the balloon would travel about 50 miles during the two hours. Figure 3 shows the flight path of the balloon. It traveled over 70 miles due to higher than expected upper air winds. An error in programming the GPS resulted in no altitude data being transmitted.

I was very excited by this part of the project since I had not expected the quality of pictures and GPS data that resulted. This proved to me personally that inexpensive technology is available to fly color TV cameras and GPS on balloons. This technology can be used by teachers and students to explore science in interesting ways. Remember, these teachers and students will need the help of hams who are

A brochure describing the project and how

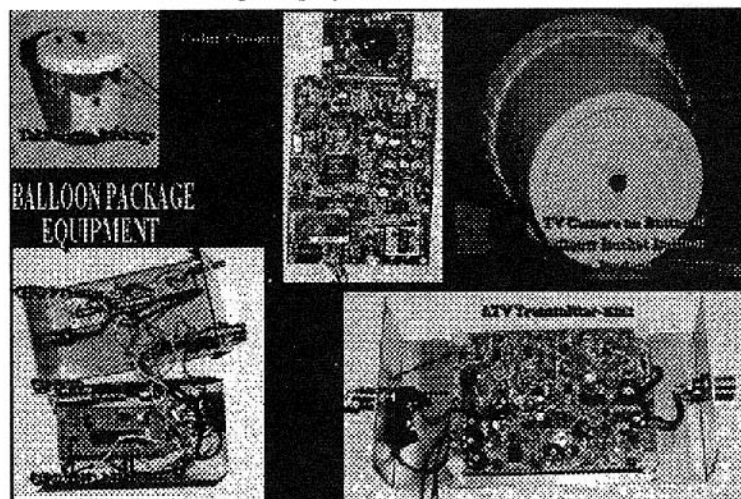


Figure 1. Balloon Payload.

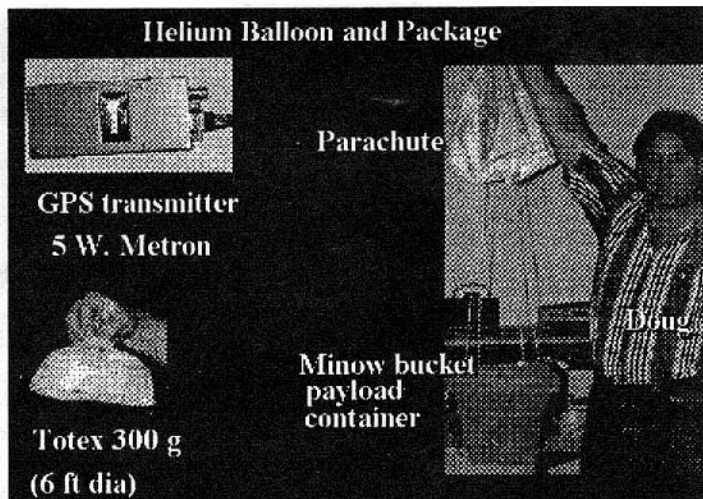


Figure 2. Totex Balloon.

knowledgeable of this technology and who are licensed to operate the transmitters. Isn't this a good way to show youngsters ham radio in an interesting light?

The launch site for the Super Loki rocket was Cape Henlopen State Park located on the southern shore of the entrance to the Delaware Bay. The specific launch site was about 1000 feet inland from the beach shoreline. The Super Loki is a meteorological sounding rocket. Its performance characteristics are shown in Figure 4. The G forces expected on launch can reach 150 to 200 G's. An additional shock of 150 G's or so occurs when the payload is explosively ejected from the Dart - the top part of the rocket.

The payload floats down from its 150,000 plus feet on a balloon-parachute called a starute. Figure 5 shows the rail gun launcher sitting on the concrete pad. The launch van and our ground station vans are shown on the left side of the picture.

Due to an ignition problem, the Super Loki failed to launch. However, as expected the Dart was ejected automatically two minutes after the motor was sent the ignition signal. The Dart was explosively thrown into the air and our payload was ejected about 100 feet straight up. It hit a tree and then fell on the sand. At ejection, the payload began transmitting and continued for about 30 minutes since we could not approach the launch area after the rocket motor malfunction. We calculated that we had about one hour of battery life which is about the time it takes for the payload to fall from its apogee.

We retrieved the payload and decided to try again the next day even though only one-half of the battery life was left. On Sunday, the Super Loki was successfully launched. However, no signals from our payload were seen or heard.

I was not disappointed at this. The Saturday launch confirmed our payload design was appropriate. Sunday confirmed that we have a lot more to learn. By the way, a Rockets for Schools program in Wisconsin launched two Super Loki's with a similar payload to ours on the following weekend. They did not get any signals from either of their payloads. We are coordinating our failure analysis with Wisconsin. Bryan Suits, WB8YKN is the payload manager for Wisconsin's Rockets for Schools project.

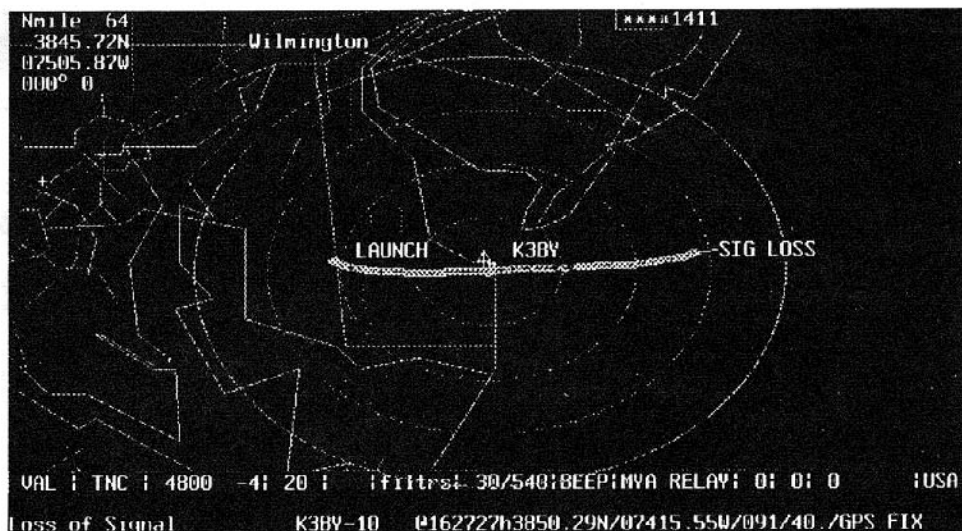


Figure 3. Balloon Flight Path

The G forces identified influenced our payload mechanical design and affected the electrical design as well. Rethinking of our design will be a part of our failure analysis as well.

Figure 6 shows the guts of our payload. Breck Smith K4CHE, was my technical consultant on the payload. Students from my classes at Delaware Technical & Community College-Terry Campus and Mr. Doug White, former faculty member, formed the team to construct the payloads.

The GPS antenna shown in Figure 6, a skirted quarter wave monopole, was taken from the meteorological package that was supplied with the Super Loki. The ATV antenna was a half-wave dipole made of spring steel and located in the middle of the

package. A link budget analysis of the TV signal from the payload predicted a line of sight distance of 27 miles. This would put the package at the limit of our ground receiving station. A special antenna rotator was designed, supplied and operated for the groundstation by Nick Federiko, N3YMS. Members of the Kent County Amateur Radio Club from Dover, DE were the ground station team.

One of the other launch activities that occurred during the day was the launch of a smaller rocket of length about 6 feet called the Spitfire. The Spitfire can reach a height of between 5 and 10 thousand feet. The payload compartment of this rocket was 4 inches in diameter and about 6 to 8 inches long. Plenty of space for interesting packages. By the way, the Spitfire is made of

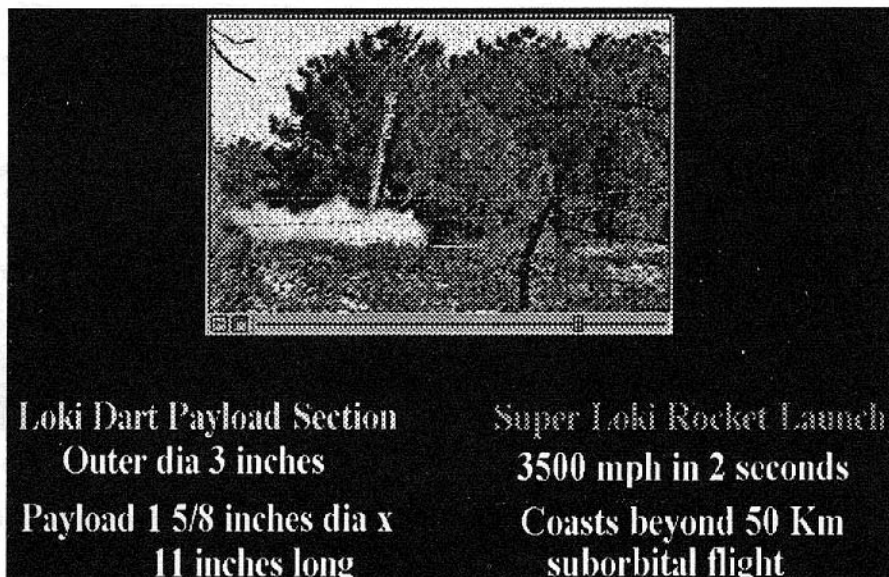


Figure 4. Super Loki Characteristics.

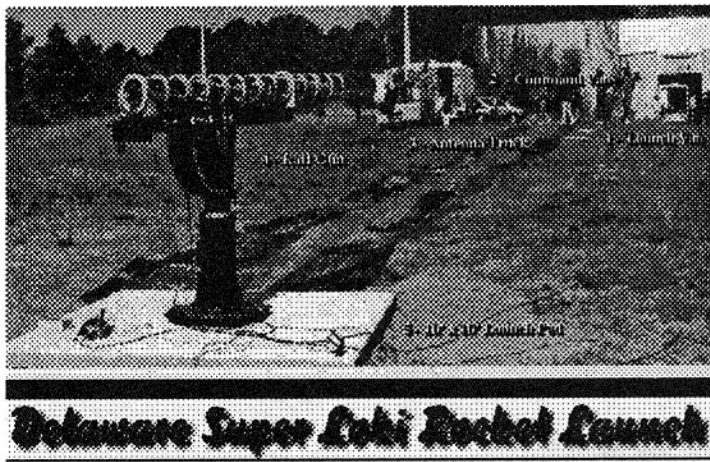


Figure 5. Rail Gun Launcher.

cardboard and lifts off with many sparks and flames. This was quite spectacular for younger students. We flew a Ramsey milliwatt VHF transmitter with a microphone to test a payload on the Spitfire as a demonstration to teachers. Due to insufficient battery power, we only received audio of the liftoff and the slapping of the parachute shroud lines against the body for about one-fourth of the flight. We were expecting to be able to find the Spitfire payload by using Direction Finding equipment and by yelling loudly while listening to the Ramsey broadcast our yells. We didn't get a chance to do this.

What's next? We are going to launch again this year. The launch date will be Saturday May 9, 1998 with Sunday, May 10, 1998 as the rain date. The launch site will once again be Cape Henlopen State Park in Lewes, Delaware. The scientific balloon will be launched at 1100 EDT and the Super Loki launch time is 1400 EDT

The Super Loki rocket payload this year will contain a continuously transmitting 2 meter beacon on 146.435 MHz. Temperature from a sensor will be transmitted and possibly GPS will be flown again. We most likely will not fly ATV on this payload. We are working on creating a realtime link to the Internet for the GPS/temperature data.

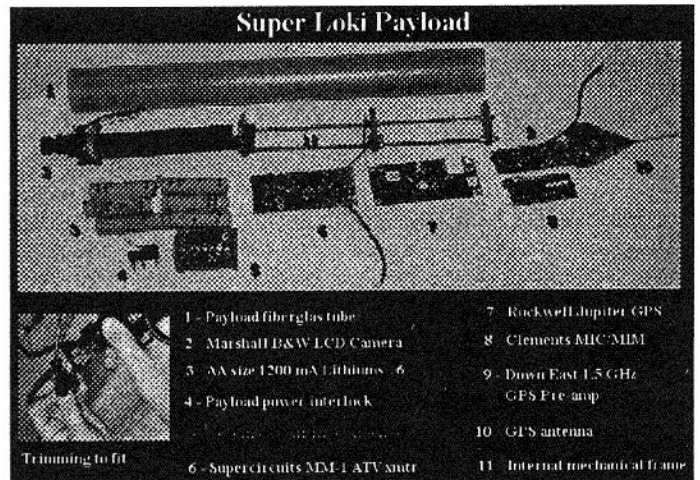


Figure 6. Super Loki Payload.

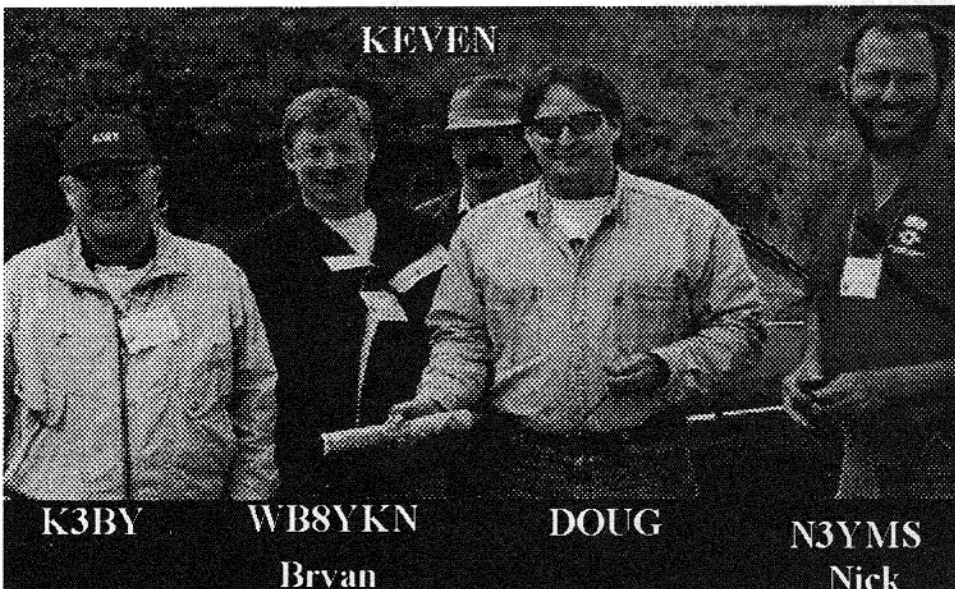
The scientific balloon payload will once again fly a color camera transmitting on an ATV transmitter frequency of 434 MHz. A GPS and temperature package similar to the one planned for the Super Loki will be flown as well. A beacon transmitter will most likely be included as well. We expect the real time link to be used for the balloon data as well.

In addition, we will be working harder to interest secondary teachers and students to become a part of our payload and ground station teams this year. The Internet link may provide an opportunity to develop this interest.

Partners in this project include my employer Delaware Technical & Community College, Terry Campus and the Delaware Aerospace Education Foundation (DASEF). Dr. Stephanie Wright, founder of DASEF, provided financial and personal support to the payload teams.

We have a new partner this year. The NASA Space Grant program provides funding for research and educational outreach. The Delaware Space Grant program, administered by the Bartol Research Center at the University of Delaware, has invited Delaware Technical & Community College to participate through the Delaware Rockets for Schools project. Funding and scientific support will be available this year.

You can get additional information, see video clips, pictures and up-to-date information by visiting the payload web page at <http://www.dtel.terry.dtcc.edu/~rocket/> and the Delaware Aerospace Education Foundation web is at <http://www.udel.edu/educ/dasef/>. You can contact me at 302-741-2802 or by email at sguccion@outland.dtcc.edu. ■



Delaware Rockets for Schools Team after retrieving the payload from the Super Loki failed launch. The payload was successfully launched the next day.

Field Ops Update: AMSAT Area Coordinators Listing

Barry A. Baines, WD4ASW (wd4asw@amsat.org)

The March/April issue of *The AMSAT Journal* has traditionally been the time for our annual listing of AMSAT's Area Coordinators. Starting on page 28 of this issue you will find a listing of the 141 Area Coordinators (plus country representatives) who donate their time and energy to help represent AMSAT within their respective communities. These volunteers may give club programs, man the AMSAT booth at local hamfests, serve as Elmers to folks getting started in Amateur Radio satellites, assist with ARRL/AMSAT Satellite Workshops, and establish AMSAT nets on local repeaters. Other activities that area coordinators have done include organizing local AMSAT gatherings and supporting AMSAT field day activities. They serve as *Ambassadors of AMSAT* in that they become the local contact for people seeking information on the amateur satellite program.

The qualifications needed for becoming an area coordinator are simple: You must be a current member of AMSAT-NA, be willing to work with people, and have an interest in representing the organization as your time and interests permit. In order to maintain contact with members of our Field Ops Team and provide them with support materials as needed, we also require that each Area Coordinator have Internet electronic mail capability. Having e-mail capability provides an effective mechanism for distributing information, sharing ideas, and keeping our area coordinators informed and thus be able to respond to queries in a timely manner. Given the variety of satellites currently in use and the diversity of interests, area coordinators are not expected to know everything about the amateur satellite program. What is important is that each volunteer be willing to seek out information, know how to get answers to questions that may be posed to them, and provide follow up with individuals seeking assistance.

AMSAT benefits from a great number of people who have stepped forward to volunteer as Area Coordinators. We now have representatives in South Dakota and West Virginia, areas that did not have an Area Coordinator in the 1997 listing. However, we still need reps in New Mexico, South Carolina and Wyoming. There are a number of states with only one Area Coordinator (Arkansas, Delaware, Hawaii, Iowa, Idaho, Kansas, Montana, New Hampshire, New Jersey, and Nevada) while other states are undermanned as well even with two-or more volunteers. We can certainly use help everywhere. If you are interested in serving as an Area Coordinator, please contact me via e-mail, wd4asw@amsat.org or telephone (home: 904-398-5185, work: 904-359-1933, home fax: 904-399-3225).

Dayton Hamvention

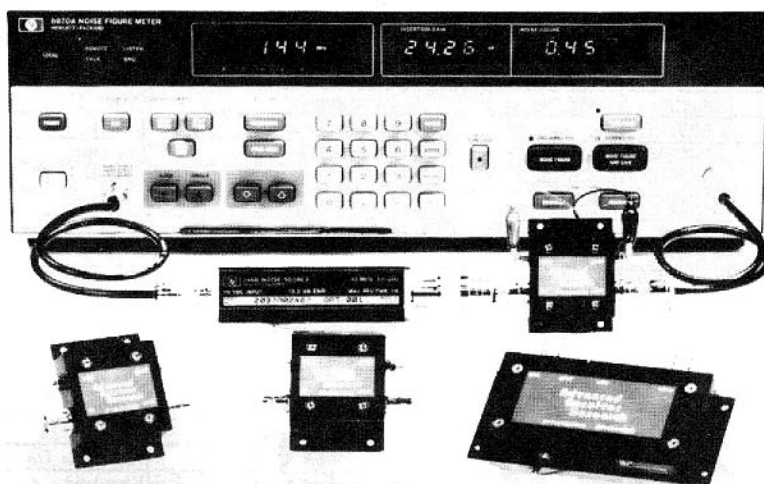
Plans are proceeding for AMSAT's participation in the 1998 Dayton Hamvention, May 15-18, 1998. As of this writing in late February, AMSAT will occupy the same booth area as in previous years. Volunteers are needed to help man the booth (1200-1800 Friday, 0800-1700 Saturday, and 0800-1400 Sunday), so please contact me if interested in helping out. (Prior experience not required!)

AMSAT will have several Forums which are expected to cover Phase 3D, SAREX/International Space Station, and an Introduction to Amateur Satellites. However,

forum schedules have not been finalized, so check the forum schedule for specific time and place for the various presentations.

Our annual Friday evening gettogether will be held once again at Elinor's Amber Rose Restaurant, 1400 Valley Street in Old North Dayton. This is the same location we've used the past two years, with excellent food at reasonable prices (about \$20.00). Prior reservations are required, so stop by the AMSAT booth on Friday afternoon if you haven't previously signed up via e-mail. Information will be posted on AMSAT-BB prior to Hamvention....See ya at Dayton! ■

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P220VDG	220-225	< 0.5	20	+12	GaAsFET	\$79.95
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SP50VDG	50-54	< 0.55	24	+12	GaAsFET	\$109.95
SP144VD	144-148	< 1.6	15	0	DGFET	\$59.95
SP144VDA	144-148	< 1.1	15	0	DGFET	\$67.95
SP144VDG	144-148	< 0.55	24	+12	GaAsFET	\$109.95
SP220VD	220-225	< 1.9	15	0	DGFET	\$59.95
SP220VDA	220-225	< 1.3	15	0	DGFET	\$67.95
SP220VDG	220-225	< 0.55	20	+12	GaAsFET	\$109.95
SP432VD	420-450	< 1.9	15	-20	Bipolar	\$62.95
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AK	WL7CMC	Chris Willey	5819 Cordova St.	Anchorage, AK	99518	(907) 561-1066	wl7cmc@amsat.org
AK	WL7BQM	Mike West	P.O. Box 452	Sterling, AK	99672	(907) 262-5930	wl7bqm@amsat.org
AL	N4NR	Dennis Dease	2588 Royal Way	Pelham, AL	35124	(205) 733-9975	n4nr@amsat.org
AL	W3PM	Gene Marcus	917 Chatterson Rd.	Huntsville, AL	35802	(205) 880-1237	w3pm@amsat.org
AR	WC5I	Mark Manes	109 Maple Shade Road	Alma, AR	72921		wc5i@amsat.org
AZ	AA7KC	Jim Weisenberger	6502 E. Pebble Dr.	Mesa, AZ	85215-2938	(602) 985-2641	aa7kc@amsat.org
AZ	NW7N	Larry Brown	2721 S. Black Moon Dr.	Tucson, AZ	85730	(520) 886-1957	nw7n@amsat.org
CA	AA6PA	Bill Rausch	1230 Jan Ave.	Hollister, CA	95023-3493	(408) 637-0622	aa6pa@amsat.org
CA	W6ISS	Tim J. Bosma	1055 West College Ave., #173	Santa Rosa, CA	95401	(707) 537-9002	w6iss@amsat.org
CA	N6DBF	John Wisniewski	1706 N. Roanoke St.	Placencia, CA	92670	(714) 524-7343	n6dbf@amsat.org
CA	N8DEZ	Stephen Smith	CYM Berth 202 #6	Wilmington, CA	90744	(310) 830-7001	n8dez@amsat.org
CA	N6TAF	Frank W. Collins	PO Box 84054	Los Angeles, CA	90073	(310) 478-3711	n6taf@amsat.org
CA	K7RR	Clifford Buttschardt	950 Pacific Street	Morro Bay, CA	93442	(805) 772-2132	k7rr@amsat.org
CA	KD6NXL	Joseph R. Rowen	788 E. Edison Street	Manteca, CA	95336	(209) 823-5425	kd6nxl@amsat.org
CA	KO6BT	Duane Naugle	10991 Patina Court	San Diego, CA	92131-2644	(619) 578-4369	ko6bt@amsat.org
CA	WB6LLO	Dave Guimont	5030 July St.	San Diego, CA	92110	(619) 275-1495	wb6llo@amsat.org
CA	WB6OVH	Gordon Fuller	7756 Tobia Way	Fair Oaks, CA	95628	(916) 961-0576	wb6ovh@amsat.org
CO	K9YKL	Jim Young	P.O. Box 583	Tabernash, CO	80478	(970) 887-2152 x4168	k9ykl@amsat.org
CO	K9MWM	Bob Ludtke	406 Yale Circle	Glenwood Sprgs, CO	81601	(970) 945-8722	k9mwm@amsat.org
CO	WB4URU	Hank Fitz	437 Chestnut Way	Broomfield, CO	80020-2941	(303) 465-0963	wb4uru@amsat.org
CO	N0VSE	John B. Gubbins	1106 W. Arapahoe Road	Littleton, CO	80120	(303) 730-3992	n0vse@amsat.org
CT	W1SL	Woody Lewis	30 Old Village Road	Bloomfield, CT	06002	(860) 242-0392	w1sl@amsat.org
CT	W4HFZ	Charles Richard	22 Queen Eleanor Dr.	Gales Ferry, CT	06335	(860) 464-9366	w4hfz@amsat.org
CT	AA1JM	David Twigg	51 Lexington St.	Bristol, CT	06010	(860) 585-1563	aa1jm@amsat.org
DE	K3BY	Sam Guccione	110 Chalet Court	Camden, DE	19934	(302) 697-6079	k3by@amsat.org
FL	KB4SYV	Ed Boyett	813 32nd STW	Bradenton, FL	34205	(813) 746-5681	kb4syv@amsat.org
FL	N4CU	Bob Walker	6601 S.W. 16th St.	Plantation, FL	33317	(954) 792-7015	n4cu@amsat.org
FL	N4IFD	Mike Crisler	17514 SW 83rd Ct.	Miami, FL	33157	(305) 378-9971	n4ifd@amsat.org
FL	AA4KN	David Jordan	825 Hickory Hill Court	Orlando, FL	32828	(407) 380-2408	aa4kn@amsat.org
FL	WB4ULT	Rick Harrelson	8144 Wellsmere Circle	Orlando, FL	32811	(407) 293-2653	wb4ult@amsat.org
FL	W4OEP	Steve Park	12122 99 Ave. N.	Seminole, FL	34642	(813) 391-7515	wb4oep@amsat.org
FL	WD4ASW	Barry A. Baines	4398 Phillips Place	Jacksonville, FL	32207-6234	(904) 398-5185	wd4asw@amsat.org
GA	KH6SAT	Rick A. Dittmer, Sr.	1666A Lunar Court	Valdosta, GA	31605-8611	(912) 241-0786	kh6sat@amsat.org
GA	AB4KN	George Daniel	401 Whitfield, Ct.	Peachtree City, GA	30269	(404) 487-0208	ab4kn@amsat.org
GA	K4EDU	Roy Robinson	3058 Angela St.	Augusta, GA	30907	(706) 860-6971	k4edu@amsat.org
GA	W4EPI	Steve Diggs	4181 Wash Lee Ct.	Liburn, GA	30047-7440	(770) 921-0315	kb4ztm@amsat.org
GA	W4OCW	Ken Wilhoit	153 Stonemill Lane	Marietta, GA	30064	(770) 428-4913	w4ocw@amsat.org
GA	KD4ANO	Mike Sheaffer	5325 Skidaway Dr.	Alpharetta, GA	30202	(770) 740-9404	kd4ano@amsat.org
GA	N7HPR	Steven Bible	208 Greenbriar Road	Kingsland, GA	31548	(912) 882-1325	n7hpr@amsat.org
Guam	KH2EI	Philip G. Weber	Box 23996, GMF	Guam	96931	(671) 637-1555	kh2ei@amsat.org
HI	WH6I	Benjamin Gorsky	1629 Wilder Ave # 1003	Honolulu, HI	96822		wh6i@amsat.org
IA	WB0NCR	Richard Machacek	RR # 1	Winthrop, IA	50682	(319) 935-3699	wb0ncr@amsat.org
ID	KR8L	Bill Parmley	4540 S. Ammon Road	Idaho Falls, ID	83406	(208) 523-4274	kr8l@amsat.org
IL	KA0SNL	Andrew Skattebo	421 N. 10th Street	Petersburg, IL	62675-1225	(217) 632-5662	ka0snl@amsat.org
IL	W9XA	Kermit Carlson	1150 McKee	Batavia, IL	60510	(708) 879-0983	w9xa@amsat.org
IL	KB9BNR	J. Dave Mayfield	2205 Barnard Ct.	Moline, IL	61265	(309) 797-3824	kb9bnr@amsat.org
IL	W9MXC	Larry H. Roberts	5319 Dover Dr.	Godfrey, IL	62035	(618) 466-0041	w9mxc@amsat.org
IN	K9EK	Edward Krome	1023 Goldfinch Dr.	Columbus, IN	47203	(812) 379-9433	k9ek@amsat.org
IN	KB9CML	Jon Haskell	10906 Lakeshore Drive West	Carmel, IN	46033	(317) 846-2394	kb9cml@amsat.org
IN	KD9QB	Ron Pogue	210 Westminster Drive	Noblesville, IN	46060-4242	(317) 773-4936	kd9qb@amsat.org
KS	N5SMJ	Ron Smith	Rt. 2 Box 125	Winfield, KS	67156	(316) 221-7775	n5smj@amsat.org
KY	W4KKJ	Bud Jenkins	2744 Lakeview Ch Rd.	Benton, KY	42025	(502) 395-7055	kb4iul@amsat.org
KY	N4PBX	Jim Ingle	203-H Thornton Court	Hopkinsville, KY	42240	(502) 886-4340	n4pbx@amsat.org
LA	K5UIC	Tom Brown	9834 Mustang Circle	Keithville, LA	71047	(318) 925-8930	k5uic@amsat.org
LA	WA9PZL	Rodger Ley	2514 Deas Street	Bossier City, LA	71111-5942	(318) 746-0356	wa9pzl@amsat.org
MA	N1OHJ	Ernie MacLauchlan	666 Main Street	S. Weymouth, MA	02190	(617) 337-7506	n1ohj@amsat.org
MA	NIKTM	Clint Walker	21 Madison Drive	East Sandwich, MA	02537	(508) 833-3890	n1ktm@amsat.org
MA	KA1JMF	John Morley	157 Catamouny Road	Tewksbury, MA	01876		ka1jmf@amsat.org
MD	WA3GOV	Howard Ziserman	11 Wellhaven Cir. # 1037	Owings Mills, MD	21117	(410) 581-9057	wa3gov@amsat.org
MD	WD8LAQ	Pat Kilroy	2520 Panther Lane	Bowie, MD	20716	(301) 249-3396	wd8laq@amsat.org
ME	W1ME	George Caswell	16 Westwood Av.	Scarborough, ME	04074	(207) 883-3362	k1mon@amsat.org
ME	N1SS	Pete Hurd	P.O. Box 1005	Houlton, ME	04730-1005		n1ss@amsat.org
ME	N1RWY	Jason Baack	RR#1 Box 1665	Frankfort, ME	04438	(207) 223-3972	
MI	N8ULU	Jerry Smyth	1921 Venice	Dearborn, MI	48124	(734) 266-3888	n8ulu@amsat.org
MI	KG8BG	Roger B. Snyder	23110 Arlington	Dearborn, MI	48128	(313) 277-2529	kg8bg@amsat.org
MI	N8QGC	John Sheets	17820 Reno Street	Riverview, MI	48192	(313) 285-2129	n8qgc@amsat.org

MI	KG8OC	Timothy S. Pickett	3101 Sloan Street	Flint, MI	48504	(810) 232-2684	kg8oc@amsat.org
MI	N8MR	Mike Rudzki	14071 Fairway	Livonia, MI	48154-5227	(313) 953-0913	n8mr@amsat.org
MN	KA3VGD	Dave Haben	7819 University Ave NE # 307	Spring Lake Park, MN	55432	(612) 785-4901	ka3vgd@amsat.org
MN	W0QIN	Robert Clark	7701 Glasgow Drive	Edina, MN	55439	(612) 944-1315	w0qin@amsat.org
MO	W0SL	Roy D. Welch	908 Dutch Mill Dr.	Ballwin, MO	63011	(314) 391-5323	w0sl@amsat.org
MO	N0PFF	Mike Koenig	895 Bellarmine Lane	Florissant, MO	63031	(314) 838-7509	n0pff@amsat.org
MO	W0ZZQ	Max Bodenhausen	116 Dogwood Lane	Highlandville, MO	65669	(417) 443-3690	w0zzq@amsat.org
MO	AA0ST	Jefferson Riff	2224 West Drake	Bolivar, MO	65613	(417) 326-7304	aa0st@amsat.org
MS	NC5Y	George Tew	1209 Springdale Dr.	Jackson, MS	39211	(601) 956-4724	nc5y@amsat.org
MS	W8JE	Terry Jones	1254 Kapalma Way	Diamondhead, MS	39525	(228) 255-5198	w8je@amsat.org
MS	N5JGK	Eddie Pettis	114 Terrace Street	Vicksburg	39180	(601) 636-2636	n5jgk@amsat.org
MS	W5VZF	Jim Akers	849 Akers Hill Road	Starkville, MS	39759	(601) 323-8389	w5vzf@amsat.org
MT	KF7KN	Charles Dapples	P.O. Box 387	Red Lodge, MT	59068-0387	(406) 446-1507	kf7kn@amsat.org
NC	KD4HCT	Rohn Daughtry	P.O. Box 547	Kenansville, NC	28349	(910) 296-0285	kd4hct@amsat.org
NC	N4TYS	Dean Perriello	P.O. Box 968	Welcome, NC	27374-0968	(336) 813-2216	n4tys@amsat.org
NC	WJ9F	Russ Platte	810 Silver Fox Circle	Concord, NC	28025	(704) 784-4949	wj9f@amsat.org
NC	WA4YMZ	Gary Rogers	2833 Ringgold Drive	Apex, NC	27502-7431	(919) 772-8865	wa4ymz@amsat.org
NC	AA8P	Harrison J. Faust	504 Culbreth Avenue	Thomasville, NC	27360	(910) 885-9100	aa8p@amsat.org
ND	W0CQ	Lynn Nelson	2700 23rd St., SW	Minot, ND	58701	(701) 839-8200	w0wbu@amsat.org
ND	KF0HR	Teran Hermanson	RR2 Box 136	Maddock, ND	58348	(701) 466-2949	kf0hr@amsat.org
NE	K0BLT	Frank Cahoy	P. O. Box 191	Bridgeport, NE	69336	(308) 262-0439	k0blt@amsat.org
NE	K0VTY	Joseph V. Murray	P.O. Box 127	Ithaca, NE	68033	(402) 623-4231	k0vty@amsat.org
NH	WA1DMV	Bill Polewarczyk	P.O. Box 243	Chester, NH	03036	(603) 887-6297	wa1dmv@amsat.org
NJ	NB2F	Dee Interdonato	118 Westvelt Place	Lodi, NJ	07644-1027	(973) 772-8340	nb2f@amsat.org
NV	N7ZEV	Frank Kostelac	4233 W. Warm Springs Rd.	Las Vegas, NV	89118	(702) 361-6080	n7zev@amsat.org
NY	NQ20	Walter Obenhofer	159 Lighthouse Rd.	Hilton, NY	14468	(716) 392-4231	nq20@amsat.org
NY	WA2EXJ	Randy Baker	PO Box 144	Madison, NY	13402	(315) 893-7194	wa2exj@amsat.org
NY	WB2UZR	Scott Schmautz	903 Spruce Drive	Holbrook, NY	11741	(516) 654-5147	wb2uzr@amsat.org
NY	KG2IC	Bruce J. Howes	6040 White Gate Crossing	East Amherst, NY	14051	(716) 689-6727	kg2ic@amsat.org
NY	N2OGB	Ronald Osborne	P.O. Box 8087	Kingston, NY	12402-8087	(914) 336-7689	n2ogb@amsat.org
OH	KB1SF	Keith C. Baker	1324 Fairgrounds Road	Xenia, OH	45385	(937) 429-5325	kb1sf@amsat.org
OH	KB8EWX	Chris Bauer	6227 Arapahoe Pl.	Dublin, OH	43017	(614) 761-3567	kb8ewx@amsat.org
OH	WB0SCD	Jim Brude	31 Quail Brace Ct.	Amelia, OH	45102	(513) 753-5183	wb0scd@amsat.org
OH	WB8IFM	Gerd Schrick	4741 Harlou Dr.	Dayton, OH	45432-1618	(937) 253-3993	wb8ifm@amsat.org
OH	WB8CKI	Terry L. Douds	344 E. Fifth Ave.	Lancaster, OH	43130-3143	(614) 687-0855	wb8cki@amsat.org
OH	KB8KVY	Sean Carey	4411 West 155th Street	Cleveland, OH	44135	(216) 476-1495	kb8kvy@amsat.org
OH	KB8GVQ	Doug Bade	7511 State Road	Parma, OH	44134	(216) 884-7892	kb8gvq@amsat.org
OH	KB8TJX	John C. O'Hara	P.O. Box 161	Wellsville, OH	43968	(330) 532-9876	kb8tjx@amsat.org
OK	WA9AFM	Tom Webb	10421 SE 55th	Oklahoma City, OK	73150	(405) 737-6716	wa9afm@amsat.org
OK	WB5OTD	Ashley Cagle	1908 SW 41th Street	Lawton, OK	73505	(405) 355-5371	wb5otd@amsat.org
OR	N7RYW	William Roth	24950 SW Rainbow Ln.	Hillsboro, OR	97123	(503) 628-0442	n7ryw@amsat.org
OR	W6GGM	Walter R. Keller	2201 Woodlawn Drive	Medford, OR	97504	(541) 734-4457	w6ggm@amsat.org
PA	KE3SU	John Distefano	2162 Springhouse Lane	Aston, PA	19014-2232	(610) 485-3386	ke3su@amsat.org
PA	N3HKQ	Kevin Smith	111 Watson Drive	Monongahela, PA	15063	(412) 258-4153	n3hkq@amsat.org
PA	KA3TKW	Tom Shingara	1 Amy Dr.	Harrisburg, Pa	17112	(717) 652-5542	ka3tkw@amsat.org
RI	WA1QXR	Ken Chaffee	P.O. Box 305	Ashaway, RI	02804	(401) 377-8490	wa1qxr@amsat.org
RI	KA1LMX	Bill McAllister	1 View Street	Warwick, RI	02886	(401) 737-0815	ka1lmx@amsat.org
SD	KG0MW	Chad Phillips	1309 West 13th Street	Sioux Falls, SD	57104	(605) 332-4261	kg0mw@amsat.org
SD	WB0YQT	Toby Wellenstein	4919 South Lewis Ave.	Sioux Falls, SD	57108	(605) 336-7120	wb0yqt@amsat.org
TN	WA4SXM	Gould Smith	8008 Chesterfield Dr.	Knoxville, TN	37909	(423) 691-2718	wa4sxm@amsat.org
TN	WB5RMG	Alan W. Sieg	4213 Reservoir Road	Kingsport, TN	37660-6228	(615) 288-7369	wb5rmg@amsat.org
TX	AB5IV	Don Schexnaider	7031 Roos	Houston, TX	77074	(713) 771-0618	ab5iv@amsat.org
TX	KA0YOS	Joe Mayfield	PO Box 51274	Amarillo, TX	79159-1274	(806) 359-5884	ka0yos@amsat.org
TX	KK5DO	Bruce Paige	P.O. Box 310	Alief, TX	77411	(281) 933-0488	kk5do@amsat.org
TX	N5EM	Ed Manuel	10430 Sagevale	Houston, TX	77089	(281) 481-6801	n5em@amsat.org
TX	W5GEL	Robert Douglas	3435 Floyd	Corpus Christi, TX	78411-1425	(512) 852-2208	w5gel@amsat.org
TX	W5IU	Keith Pugh	Box 121576	Ft. Worth, TX	76121	(817) 292-5633	w5iu@amsat.org
TX	W5JUV	Doug Hutton	8107 Fremont	Lubbock, TX	79423	(806) 745-1504	w5juv@amsat.org
TX	KC5YRE	Jerry Ervine	721 Tulipan/Box 5204	Hidalgo, TX	78557	(956) 843-8298	kc5yre@amsat.org
UT	N7QOC	Paul M. Urie	622 East 3180 North	Provo, UT	84604-4200	(801) 374-6036	n7qoc@amsat.org
UT	W7KBM	Ken Oliver	2126 Cobble Creek Drive	Cedar City, UT	84720	(801) 586-9033	w7kbm@amsat.org
UT	N7SFI	Randolph Kohlwey	135 St. Moritz Way	Park City, UT	84098-5249	(435) 649-7035	n7sfi@amsat.org
UT	N7MPM	Tom Calder	Box 220176	Centerfield, UT	84622		n7mpm@amsat.org
VA	N4MW	Dave Meier	6560 Marl Springs Drive	New Kent VA	23124	(804) 932-3641	n4mw@amsat.org
VA	WY4D	Ben A. Hall	836 Ridgecrest Drive	Roanoke, VA	24019	(703) 366-1340	wy4d@amsat.org
VI	NP2L	Malcolm Preston	Box 1318	Cruz Bay, VI	00831	(340) 693-8782	np2l@amsat.org
VT	WE1U	Bob DeVarney	RR1 Box 1434	Shelburne, VT	05482-9108	(802) 238-7007	we1u@amsat.org
VT	N1GZZ	Thomas Whitney	RR1, Box 1945	Hinesburg, VT	05461	(802) 482-4443	n1gzz@amsat.org
WA	KA7LDN	Joe Holman	Box 37	Redmond, WA	98073	(206) 788-8427	ka7ldn@amsat.org
WA	W7HGK	Art Coulombe	21 Yakima Street	Walla Walla, WA	99362	(509) 522-0834	w7hgk@amsat.org
WI	N9UUR	Gary S. Bargholz	8273 N 53rd	Brown Deer, WI	53223	(414) 355-6922	n9uur@amsat.org

WI	N9MYK	Richard T. Sell	N64 W24186 Main St., Apt. 8	Sussex, WI	53089-3064	(414) 820-5283	n9myk@amsat.org
WV	W8XF	Mac E. McMillian	2537 Larwood Drive	Charleston, WV	25302	(304) 346-6006	w8xf@amsat.org
WY	Vacant						
Canada	VE2SB	Daniel Richer	P.O. Box 43	Joliette, QC	J6E 3Z3	(514) 752-5037	ve2sb@amsat.org
Canada	VE2OTT	Richard Provencal	245 Sharron	Otterburn PK, Quebec	J3H IX7		ve2ott@amsat.org
Canada	VE3FRH	Robin Haighton	2028 Cheviot Court	Burlington, Ontario	L7P 1W8	(905) 335-5892	ve3frh@amsat.org
Canada	VE3HCR	Dave Oman	330 Winnifred Drive	Keswick, Ontario	L4P 3B5	(905) 476-5973	ve3sat@amsat.org
Canada	VE6ATS	Paul Barrow	Box 655	Devon, Alberta	T0C 1E0	(403) 987-3746	ve6ats@amsat.org
Canada	VE6ITV	Scott Smith	Box 4462	Barrhead, Alberta	T7N1A3	(403) 584-2517	ve6itv@amsat.org
Canada	VE7VWV	Ron Seiler	4001 15th Crescent	Vernon, BC	V1T 7H5	(604) 545-3124	rgseiler@bcsc02.gov.bc.ca
Canada	VE7XQ	Tony Craig	20691 - 45A Ave.	Langley, BC	V3A 3G3	(604)-534-1296	ve7xq@amsat.org
Canada	VE7MAL	Malcolm Scrimger	1278 Rockcrest Ave.	Victoria, BC	V9A4W2	(604) 386-9443	ve7mal@amsat.org
Canada	VE4XA	Bob Mitchell	15 Morning Glory Crescent	Winnipeg, Manitoba	R2J 3T5	(204) 257-4996	ve4xa@amsat.org
Country Representatives							
	HH2B	Bernard Russo	P.O. Box 38	Port au Prince, Haiti			hh2b@amsat.org
	HR2KOS	Ricardo 'Rick' Denis	P.O. Box 1224	San Pedro Sula, Honduras, 21105		(504) 53-0136	hr2kos@amsat.org
	A71EY	Mohamed Althani	P.O. Box 2260	Qatar			a71ey@amsat.org
	KX4Y	Dieter K. Schliemann	29 Soi Ruamrudee 1, #812	Ploenchit, Bangkok, Thailand, 10330			kx4y@amsat.org

Satellite Orbital Elements

Ray Hoad, WA5QGD

Satellite	AO-10	AO-27	FO-20	FO-29	RS-10/11	RS-12/13	RS-15
Catalog Number	14129	22825	20480	24278	18129	21089	23439
Epoch Time	98067.13245924	98070.70171494	98067.33772390	98068.02383613	98070.01029031	98070.09123082	98069.50879029
Element Set	539	626	35	146	463	49	285
Inclination	26.6908	98.5163	99.0758	98.5163	82.9217	82.9204	64.8157
RA of Node	98.6975	143.5773	344.6178	77.7625	41.4989	80.7132	82.1972
Eccentricity	0.6003521	0.0008208	0.0541861	0.0350507	0.0010563	0.0027797	0.014583
Arg of Perigee	198.582	171.4077	139.5177	219.6763	195.2713	276.3678	80.323
Mean Anomaly	123.7121	188.7236	224.7572	137.8245	164.8123	83.4312	281.4131
Mean Motion	2.0588426	14.27760109	12.83241609	13.5263806	13.7239105	13.74092981	11.27528539
Decay Rate	-0.00000314	0.0000002	0.00000003	-0.00000048	0.00000017	0.0000003	-0.00000039
Epoch Rev	11079	23224	37858	7692	53683	35581	13196
Satellite	RS-16	UO-11	UO-14	AO-16	DO-17	WO-18	LO-19
Catalog Number	24744	14781	20437	20439	20440	20441	20442
Epoch Time	98071.19393346	98067.88942793	98068.21892365	98069.20470080	98069.79358077	98070.77721485	98068.27412094
Element Set	161	41	337	132	130	138	135
Inclination	97.2594	97.8678	98.4978	98.519	98.5241	98.5231	98.5274
RA of Node	336.3429	44.0241	148.8751	153.4029	155.038	155.866	154.2444
Eccentricity	0.0005024	0.0010602	0.0011053	0.0011435	0.00115	0.0011949	0.0012079
Arg of Perigee	204.5733	236.267	142.606	142.3326	138.7616	136.8685	143.0262
Mean Anomaly	155.528	123.7529	217.5891	217.8665	221.4437	223.3435	217.1753
Mean Motion	15.34130621	14.6968234	14.30001851	14.30044486	14.30188599	14.30153667	14.3027262
Decay Rate	0.00006632	0.00000303	0.00000049	0.00000061	0.00000012	0.00000036	0.00000031
Epoch Rev	5713	75013	42409	42425	42437	42451	42418
Satellite	UO-22	KO-23	KO-25	IO-26	Mir	Hubble	Phase 3D (Est)
Catalog Number	21575	22077	22828	22826	16609	20580	99934
Epoch Time	98067.19503431	98067.71623293	98069.70839208	98069.73851119	98071.52779204	98070.77216725	96260.25520000
Element Set	840	729	600	621	325	39	3
Inclination	98.267	66.0794	98.5142	98.5187	51.6582	28.4686	60.0203
RA of Node	122.8951	311.3713	143.0288	142.9599	175.387	129.9042	342.7876
Eccentricity	0.0007068	0.0006357	0.0009797	0.000848	0.0005378	0.0014758	0.6752895
Arg of Perigee	174.9146	333.8645	158.8384	176.3623	112.1406	94.861	180.1221
Mean Anomaly	185.2113	26.2044	201.3203	183.762	248.0177	265.366	179.5089
Mean Motion	14.37119695	12.86307391	14.28219279	14.27871251	15.62637869	14.86632516	1.51063698
Decay Rate	0.00000063	-0.00000037	0.00000016	0.00000022	0.00015036	0.00000609	0.0002
Epoch Rev	34840	26177	20025	23212	68893	23290	2

Bernard "B.J." Arts, WT0N, SK

Satellite operators around the world were saddened to learn about the death of Bernard Arts Jr., WT0N, of Hibbing, Minnesota. Known to all as B.J., he was 37 years old at the time of his death. WT0N had suffered for several years with severe diabetes and succumbed to an acute heart attack early on the morning of February 9, 1998. B.J. was born April 29, 1960 in Minneapolis, Minnesota. Services were held February 11, 1998 at the Blessed Sacrament Catholic Church with internment at Maple Hill Cemetery in Hibbing.

B.J. was very active in amateur satellite work and held several positions in AMSAT, acting as ANS Bulletin Editor until his death. In addition to AMSAT, B.J. was a life member of the ARRL, serving as an Official Observer, Assistant Emergency Coordinator in northern St. Louis County, and a Skywarn volunteer. He also was president of the Midrange Amateur Radio Club and was active in Army MARS as AAR5EL. In addition to being an active VHF'er, WT0N had been employed at WDIO-TV in Duluth, Minnesota and KSTP-TV in Minneapolis, where he won an Emmy Award for his work. He had also worked as an announcer for WMFG radio in Hibbing.

AMSAT-NA President Bill Tynan, W3XO, expressed shock at the news of Arts' death. "He was a big help to AMSAT and will be missed by all his friends around the world," he said. Keith Baker, KB1SF, AMSAT-NA Executive Vice President, was also saddened, saying, "This is a real shock to me personally, as I just spoke with B.J. via AO-27 right before his death."

Survivors include his Mother and a sister. B.J.'s family has requested that any memorials in B.J.'s name be made to the National Diabetes Foundation or the AMSAT Phase 3D fund as a fitting tribute to WT0N. (via Dan James, NN0DJ)

Mel Roman, KF2WN SK

It is with great sadness that I report the death of Mel Roman, KF2WN. Mel started out many years ago as an Area Coordinator. Although he had to resign that position due to poor health, he remained an active AMSAT volunteer. Mel ran the AMSAT Bulletin Board in New Jersey. For many, he was the only means of obtaining the AMSAT news and Keplerian elements. Mel died at the age of 54 on January 21, 1998 from complications associated with diabetes. His warm personality and willingness to help will be greatly missed. (via Martha Saragovitz)

AO-27 and the Ice Storm

Dan Huton, VA3JDH, of Mississauga, Ontario sent the following message via e-mail on his use

of AO-27 during the recent ice storm that affected eastern Canada and New England.

Last January, I brought my Yaesu FT-530 and Arrow Satellite antenna with me while I was visiting my parents in Montreal (FN35). Glad I did! Wow, was I in for a shock as my four day visit ended up being a ten day visit in a war zone. We had no hydro power for several days, no heat, food was scarce, no banking machines, gas pumps...you get the idea. I came back home to Toronto once Mom and Dad's power was restored. The ice storm even toppled down some AM transmitter towers. It was literally a war zone with power lines toppled and trees broken everywhere. That ice storm is one the people in Quebec will never forget.

Enter ham radio. I was really glad I had the HT, the Arrow antenna, and a portable lead acid battery as it kept the 7.2v pack topped out. I did print off a list of times and az/el for AO-27 passes so I was able to make contacts back home in Toronto and elsewhere in the States. It was nice to hear the Bird silent while I was passing info to Steve VA3SF back in Toronto about my situation. There were also a couple of US hams that asked if I had traffic as well (nice touch). I tried to go on the bird when I could, but weather conditions prevented me a few times. (That freezing rain was like rice being thrown in the face!) I also got many stares from people as I was working AO-27. Some thought I was checking the hydro lines! I was fortunate that my traffic to AO-27 and HF nets was routine and not emergency, but I'm sure others were a lot worse than I was. Amateur Radio is not only a hobby but a skill that can be beneficial, especially when others are in need of our help and knowledge. However, AO-27 is a busy bird. We need more like it. You never know when an emergency hits, and this repeater in the sky sure helps; at least for me it was comforting to hear other hams several hundred kilometers away, and talk to them as well.

AO-27 was only a part of my ham radio experience during the ice storm in Montreal. I salvaged some lead acid batteries from a friend's go-cart so I had basically limitless power while the HT was operating indoors so we could keep in contact with other hams. For a few days it was a survival tactic as I had to take care of Mom and Dad. We ended up at a friend's place for the last few days as they had power restored so there was heat.

Washington DC Area AMSAT Meeting

All are invited to the next semiannual Maryland-DC area AMSAT Meeting and Space Seminar. The gathering will take place on Sunday afternoon, April 19, 1998 at 1300 at the Visitor Center at the NASA Goddard Space Flight Center in Greenbelt, Maryland. Check for the agenda and all the latest MDC developments by browsing the Local Maryland-DC Area AMSAT Web Page at <http://garc.gsfc.nasa.gov/~simstat/ssamsat.html>.

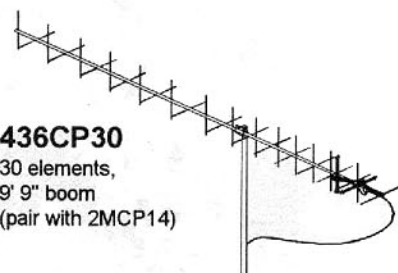
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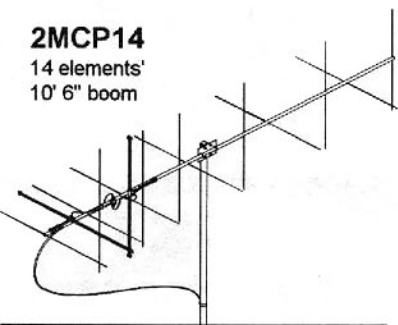
436CP42-U/G

42 elements,
18' 10" tapered boom
(pair with 2MCP22)



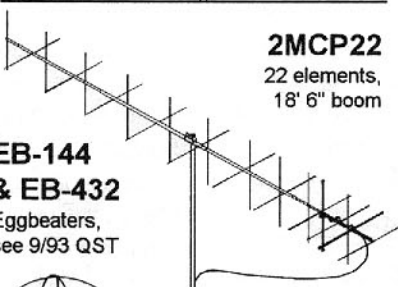
436CP30

30 elements,
9' 9" boom
(pair with 2MCP14)



2MCP14

14 elements'
10' 6" boom

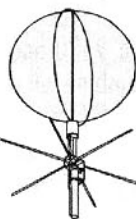


2MCP22

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— QST Magazine, March 1997
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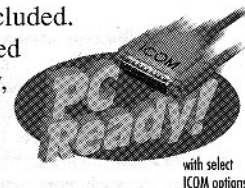
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